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2016 Basewide Annual Monitoring and Operations Report for CERCLA and Non-CERCLA Sites, Former George Air Force Base, Victorville, San Bernardino County

The Lahontan Regional Water Quality Control Board (Water Board) received the *Final 2016 Basewide Annual Monitoring and Operations Report for CERCLA and Non-CERCLA Sites, Former George Air Force Base* (AMR) on June 22, 2017. After review of the 2016 AMR, Water Board staff are concerned regarding the contents of the AMR, including:

1. Evaluations that have been previously rejected by the regulators are included, as well as unsupported or inadequately supported statements and conclusions.
2. Critical data gaps are not identified.
3. Planned activities are not discussed or are incomplete.

The Air Force issues the AMRs as final documents with the understanding that regulatory comments will be addressed in the subsequent AMR. Water Board staff have not commented on the AMR in the recent years because documents with comment periods designated in the former George Air Force Base's (GAFB) Federal Facility Agreement take priority over a final AMR, which will not be reissued in response to comments.

While referring to the 2015 AMR as a resource document, Water Board staff noted some of the problems cited above. Therefore, Water Board staff prioritized review of 2016 AMR. Because of the extensive contents of the AMR, this letter only includes comments based on staff's review of the text, tables and figures. Water Board staff may provide comments on the appendices at a later date.

General Comments

Comment 1: Timeframe for Response to Comments

We request that the Air Force respond to these comments within 60 days from the date of comment letter to ensure that all issues are resolved in a timely manner and before the next sampling event. Please address the comments in this letter, Department of Toxic Substances Control (DTSC) comments in Enclosure 1, and the specifically referenced comments and discussions in prior Water Board correspondence in Enclosures 2 through 4.

Comment 2: AMR Contents

The second paragraph of Section 1.0, Introduction, states the AMR includes the following contents:

- Documentation of the monitoring and operation activities;
- Presentation of data for:
  - Groundwater and soil vapor monitoring,
  - Soil vapor extraction (SVE) system operation, maintenance and monitoring,
  - Landfill monitoring and maintenance,
  - Free product (light non-aqueous phase liquids [LNAPL]) recovery systems;
- Evaluation of data for regulatory compliance for sites with records of decisions and non-CERCLA sites;
- Recommendations for sites with active remedies.

Water Board staff concur with this list of contents as appropriate for annual reporting with the exception of the restriction of recommendations to sites with active remedies. See Comment 5 regarding the inclusion of recommendations and the need to obtain regulators concurrence with recommendations.

However, the AMR is extremely large and would benefit from a more focused approach. Water Board staff recommend that the remedial project managers (RPMs) evaluate the objectives and functions of the AMR in an effort to maximize its usefulness and to expedite its production. Water Board staff offer the following suggestions to achieve these ends.

a. The regulators and the Air Force reach concurrence on the contents and format of the AMR. For example, Water Board staff use Excel pivot tables that are a compilation of historic and current groundwater water monitoring data. Currently, the State has to expend resources to recreate this table each year. It would be helpful if the AMR included these pivot tables in electronic format.
b. The document is extremely large, and its compilation must be time consuming since the document is not submitted to the regulators until a year after the spring monitoring event. Water Board staff are unable to provide a timely review because of the extensive material included in the AMR and the higher priority of the GAFB documents that are subject to revision and approval in accordance to the Federal Facility Agreement. Water Board staff suggest that the Air Force consider the following actions.
   - Divide the AMR contents into smaller, focused documents that can be submitted in a timely fashion, such as operations and maintenance (O&M) reports for SVE systems, free product recovery systems, landfills, and a report on groundwater monitoring.
   - Conduct monitoring of all wells in one event, spring or fall, so that the annual reports can be produced in a timely fashion.
   - Focus on reporting the data and identifying issues that impact the groundwater monitoring networks or remedial systems, such as plume migration beyond the monitoring network. Eliminate evaluations and conclusions that are outside of the scope of the AMR, i.e., evaluation of monitored natural attenuation (MNA) at sites where it is not the selected remedy and there is no approved MNA monitoring program (see Comment 3).
   - Provide conclusions, recommendations and planned activities in a format that can be reviewed and approved by the regulators, i.e., in a format that is not submitted as final.

Additionally, staff identified three major problems with the contents which should be included in an upcoming RPMs' discussion of the AMR contents. These problems are described in Comments 3, 4, and 5.

Comment 3: Inclusion of Contents Beyond the Scope of AMR and Unsupported Statements

The AMR goes beyond the stated contents, e.g., evaluations and conclusions regarding remedies that that have not been adopted in a decision document and, in fact, have been rejected by the regulators as unacceptable. The AMR also contains conclusions that are not supported in the AMR or in any referenced document.

Water Board staff do not concur with the Air Force's decision to use the AMR as a vehicle to put forth analysis, methods, conclusion, and remedies that have clearly been rejected by the regulators or that are not supported by information in references to regulatory-approved documents. The presentation, discussion, and conclusions of these analyses should be removed from future AMRs. Each AMR becomes part of the public record without qualification. Conclusions that have been rejected or are unsupported may be inferred by the public or other agencies as approved by the regulators. As stated on Comment 2, the RPMs should reach concurrence on the AMR contents and the AMR should not go beyond agreed-upon contents.

Comment 4: Data Gaps and Plume Migration

The AMR does not acknowledge or highlight data gaps, data limitations, or deficiencies in the monitoring systems (e.g., inadequate monitoring downgradient of plumes), and its evaluation of plume migration is inadequate. The focus of the data analysis of groundwater monitoring should be plume migration, data gaps, adequacy of the monitoring program under current and anticipated conditions, and other analysis as agreed upon by the RPMs. Instead, the AMR focuses on temporal trends in individual wells and fails to identify plume migration and data gaps in the monitoring well network.

Comment 5: Recommendations and Planned Activities

The AMR is lacking in the discussion of recommendation and planned activities for sites. Water Board staff could only identify two site-related sections that identified recommendations and planned activities. These discussions were included under conclusions. To better highlight recommendations and planned activities, each site-specific section should include a "Recommendations and Planned Activities" heading. The contents of the Recommendations and Planned Activities sections should be submitted to the regulators for review and concurrence (see the last bullet under Comment 2.b). Recommendations and planned activities should be discussed for each site, even if there are no new activities planned and the section only summarizes the continuation of the existing activities. Any proposed shutdown of a remedial system should be highlighted under this section and also submitted to the regulators for review and concurrence prior to its implementation.

Comment 6: Regulatory Requirements and Compliance for CERCLA Sites

Each site-specific section has one subsection entitled "Regulatory Framework" and, several subsections later, a second subsection entitled "Regulatory Compliance Summary." However, the discussions for CERCLA sites are limited to compliance with remedial action objectives (RAOs) in decision documents. Water Board suggest the RAO evaluations be discussed in a future RPM meeting and the following recommendation be considered in this meeting.

a. Conclusions regarding compliance with RAOs should be submitted to the regulators for review and concurrence prior to inclusion in a final document such as the AMR.
b. If a decision document has not been adopted for a CERCLA site, then any existing RAOs from approved documents, e.g., feasibility study or proposed plan, should be included and evaluated. If no such documents exist, discussion of RAOs and meeting MNA criteria should not be identified.
c. For brevity and to eliminate redundancy, consider combining the two subsections, i.e., Regulatory Framework and Regulatory Compliance Summary, into one.
d. Revise the title of the subsection to reflect that it contains a discussion of RAOs, not the applicable regulations.

Comment 7: Regulatory Requirements and Compliance for Non-CERCLA Sites

The AMR states that regulatory compliance cannot be determined at the non-CERCLA sites since none of these sites have corrective action plans (CAPs) in place. However, State requirements, as specified below, apply to site investigations, cleanups, and closures, whether or not a corrective action has been accepted by the regulators. The AMR should list these requirements, discuss existing and planned efforts to achieve compliance with the requirements, and include a schedule for documents to support compliance efforts. Conclusions regarding compliance with regulatory requirements should be submitted to the Water Board for review and concurrence prior to inclusion in a final document, such as the AMR. Also, see Comment 6.c regarding combining the two regulatory sections into one section.

a. In a letter dated November 15, 2005, the Air Force agreed to following State requirements for petroleum sites as specified in Water Board's conditions for acceptance of sole oversight responsibilities for the petroleum sites (Water Board letter dated October 18, 2005). The AMR should evaluate the status of compliance with these requirements, which are as follows.
    - Applicable sections of the California Health and Safety Code, including, but not limited to Corrective Action Requirements (section 25296.10), testing for methyl tertiary butyl ether (MTBE) (section 25296.15), notification to all current Record Owners of Fee Title (section 25296.20), Abandonment of UST Systems (section 25298), and Sample Analysis in Accredited Laboratories (section 25298.5);
    - Applicable sections of California Code of Regulations, title 23, chapter 16 including, but not limited to Vadose and Groundwater Monitoring and Well Construction (Article 4), Initial Abatement and Free Product Removal (Article 5), and Corrective Action (Article 11); and
    - Applicable State Water Resources Control Board's and Regional Board's Policies and Plans including, but not limited to State Board Resolutions 68-16, 88-63, and 92-49 and the Water Quality Control Plan for the Lahontan Region (Basin Plan).

    Additionally, in 2012 the State Water Resources Control Board adopted the Low-Threat Underground Storage Tank (UST) Case Closure Policy, which has been applied at some GAFB petroleum sites and may be applicable to others.
    Furthermore, in accordance to Water Board's conditions for acceptance of sole oversight responsibilities for the petroleum sites (Water Board letter dated October 18, 2005), the Air Force submitted a schedule for deliverables to achieve compliance at the petroleum sites, which included a 2006 date for a final CAP (Air Force letter dated December 15, 2005 letter). This date has been postponed for various reasons and progress at the large petroleum sites (e.g., SS030 and ST067b) has stalled. Water

Board staff find that a revised schedule to achieve compliance is necessary to move these sites forward. Please submit a revised schedule within 60 days from the date of this letter.

b. For the non-CERCLA, site OT071 (dieldrin groundwater plume), the AMR should discuss compliance with the applicable regulations as cited in Water Board letter dated September 13, 2013. The applicable regulations include the following.
    - Applicable State and Regional Board Policies and Plans including, but not limited to, State Board Resolutions 68-16, 88-63, and 92-49 and the Water Quality Control Plan for the Lahontan Region (Basin Plan).
    - Porter-Cologne Water Quality Act.

Comment 8: Regulatory Authority

Finally, the Air Force and the Water Board do not appear to be in agreement on the Water Board's regulatory authority at the non-CERCLA sites, as evidenced by the AMRs failure to acknowledge that Water Board requirements apply with or without a CAP and by the fact that the Air Force has shut down remedial systems without seeking Water Board approval. At one site, SS084, the Air Force dismantled and removed the remedial system without consulting Water Board staff who were not aware that the system had been dismantled until a year later when the action was included in the 2016 AMR. In some cases, the remedial systems have remained shut down for years for the stated reason of rebound testing but the results of the tests, which are usually completed in a few months, are not reported to the Water Board.
Water Board staff consider these unapproved shutdowns of interim remedial systems to be in violation of Water Board requirements and contrary to the Air Force's agreement to follow these requirements. As a first step to resolve the Air Force's failure to adhere to Water Board requirements, Water Board staff requests that the Air Force submit corrective actions for the non-approved shutdown of remedial systems within 60 days of the date of this letter.

Comment 9: Institutional Controls

Many of the sites have institutional controls (ICs) as a component of a selected remedy and the discussion of ICs for those sites should include references to the instrument that contains the ICs and current status of their implementation, oversight, and effectiveness. Alternatively, the Air Force could submit a separate IC report (see first bullet in Comment 2.b.)

Comments on Section 1 Introduction

Comment 10: Section 1.0 Introduction

The use of the term SEDA (Southeast Disposal Area) should be revised for consistency with the Operable Unit 3 (OU3) Record of Decision (ROD), which defined the SEDA as consisting of nine specific disposal sites in Parcel K, which was transferred to the Federal Bureau of Prisons. Water Board staff do not concur with the AMR's statement that the referenced document (AFCEC, 2014) changed the ROD's definition of the SEDA sites. All future AMRs should adhere to the site nomenclature of the OU3 ROD. This comment applies to all references to SEDA in the AMR.

Comment 11: Section 1.0 Introduction

The AMR's statement implying that only six disposal sites are included in a ROD is inconsistent with the OU3 ROD, which selected remedies for 15 disposal sites. Please reconcile this inconsistency in future AMRs. This comment applies to all portions of the AMR that discuss the OU3 disposal sites.

Comment 12: Section 1.5.1 Operable Unit 1 Sites

The discussion of the Technical and Economic Feasibility Analysis (TEFA) for CG070 should be revised to clarify that the TEFA has not been finalized and the Proposed Plan was not accepted by the U.S. Environmental Protection Agency (EPA) (letter dated March 21, 2014) or Water Board (letter dated March 21, 2014). Additionally, the Water Board went on record as not concurring with the Proposed Plan remedy of monitored natural attenuation (MNA) in its March 2014 letter. In a March 2017 joint letter, the EPA and Water Board stated that MNA would not be adequate to remediate CG070 and an active remedy was necessary. In a letter dated August 14, 2017, the Air Force agreed to conduct a pilot study for active remediation of groundwater contamination. The section should also note that the ROD Amendment is on hold pending the Air Force and the regulators reaching agreement on a remedy for this site.

Comment 13: Section 1.5.4 Non-CERCLA Sites

The statement that "Corrective actions for non-CERCLA petroleum sites are being conducted under Resolution 92-49 of the California Underground Storage Tank Program." is incorrect and incomplete. Resolution 92-49 is a promulgated Statewide policy that applies to the investigation, cleanup, and abatement of discharges and it's application is not restricted to UST sites. Revise this statement for consistency with Comment 7.a regarding applicable regulations for non-CERCLA petroleum sites.

Comment 14: Section 1.5.4 Non-CERLCA Sites

The discussion of CAPs for petroleum sites should be deleted or revised to include the fact that the draft CAPs for SS030 and ST067b were rejected as inadequate by Water Board staff (Water Board letters dated November 26, 2014 and February 26, 2016). The expected dates for submittal of new draft CAPs should be included. See Comment 7.a regarding the petroleum CAPs.

Comment 15: Section 1.5.4 Non-CERCLA Sites

This section refers to "active sites" and "inactive sites", but it is not clear what is meant by these terms. According to Water Board's database, Geotracker, at least two of the sites referred to as inactive (i.e., the Buckeye site and ST067a) are open sites. Please define the meaning of the terms. Additionally, specify which sites are open and subject to further action, and which are closed, i.e., the regulatory agency or agencies have concurred with recommendations of no further action (NFA). Include a reference to the written documentation of regulatory concurrence with the NFA determination. This comment applies to all other portions of the AMR that refer to a site as inactive, active, or closed. Finally, the AMR should include a discussion of plans for addressing the open petroleum site, ST067a.

Comment 16: Section 1.7.2 Soil Vapor Extraction System Operation and Maintenance

The 2017 AMR should provide an explanation for the continued shut down of any SVE systems (e.g., ST054, ST057, FT019a, FT019c, and ZZ051) and when the system will be restarted. This section should state where the rebound testing for ZZ051 is reported or will be reported. This comment also applies to the site-specific sections of the AMR. Also see Comment 8 regarding non-compliance with Water Board requirements.

Comment 17: Section 1.7.2 SVE System Operation and Maintenance

This section states that the SVE system at Site SS084 was moved to Site ST067b in July 2016. Water Board staff were not consulted regarding the removal of the system and were not aware of its removal until reviewing the 2016 AMR (submitted June 2017). Please revise this section to

summarize the Air Force's agreement to resume SVE and the planned date for the resumption of the system. Also see Comments 7.a and 8 regarding applicable regulations, regulatory authority over investigation, cleanup, and closure of petroleum sites, and non-compliance with these requirements.

Comment 18: Section 1.7.3 Free-Product Recovery System Operations

The shutdown of the free product (i.e., LNAPL) recovery system was not approved by Water Board staff. This section should explain why the system was shutdown and describe plans for resumption of the system in accordance to the applicable regulations that require LNAPL be removed to the maximum extent practicable. Also see Comments 7.a and 8. regarding applicable regulations and authority over investigation, cleanup, and closure of petroleum sites, and non-compliance with these requirements.

Comment 19: Section 1.7.4 Landfill Monitoring and Maintenance Activities

The Long-term Monitoring and Maintenance Plan (LTMMP) has been amended several times. The reference to the LTMMP should be revised to include all amendments that are relevant to the landfill sites.

Comment 20: Section 1.7.5 Groundwater Modeling

The document that reported the modeling effort for ST067b, the draft CAP, was rejected by Water Board staff (letter dated February 26, 2016). Therefore, the results should be deleted from the AMR (see Comment 3).

Comments on Section 2 Scope of Work and Methodology

Comment 21: Section 2.1 Groundwater Monitoring

This section states that well information regarding Air Force and non-Air Force wells is included in Table 2-1. However, Table 2-1 does not include the Victor Valley Wastewater Reclamation Authority (VVWRA) water supply wells or the private wells along Shay Road. The table should be reviewed and revised for completeness.
The Air Force should request permission to sample the VVWRA wells and the private wells. The analysis of these wells should include GAFB groundwater COCs, including volatile organic compounds, dieldrin, and the emergent contaminants: perfluorooctane sulfonate (PFOS) and perfluorooctonaic acid (PFOA). PFOS and PFOA have been detected at GAFB in the Upper and Lower Aquifer at concentrations above the EPA level. Additionally, the Adelanto supply well field, Aldelanto-4, if available, should also be analyzed for PFOS and PFOA.

Comment 22: Section 2.1.1.4 Well Purging

Please explain how the Adelanto well field will be monitored in the future if water supply well, Adelanto-4, is not available for sampling. Also, the discussion of the wells that were not sampled should be highlighted under Section 2.1.1.6, Sample Collection, rather than under Well Purging.

Comment 23: Section 2.1.1.4 Well Purging

The well purging/sample logs were supplied to Water Board staff upon request. The criteria for stability shown on the logs vary from the stability parameters included in the GAFB Quality Assurance Project Plan (QAPP). Please ensure the all relevant portions of the QAPP are followed, including stability parameters in future sampling events, and that corrective actions are documented in the AMR and implemented. Also, please provide these logs in electronic format in future AMRs.

Comment 24: Section 2.1.2.5 Quality Assurance Activities

This section should summarize any quality assurance issues that were identified in the audits. Future AMRs should include the quality assurance documentation as well as corrective actions in electronic format for completeness.

Comment 25: Section 2.2.2.1. Equipment Decontamination

This section states that equipment decontamination was not necessary because dedicated tubing was used for sampling. However, this statement does not apply to well sounding equipment, i.e., water level meters. Please clarify this statement.

Comments on Section 3 Basewide Groundwater Monitoring

Comment 26: Section 3.2.1 Upper Aquifer, Basewide

The measures that the Air Force is considering to reduce the groundwater mound in the vicinity of the City of Victorville pond adjacent to the golf course should be discussed with Water Board staff. Please include this as an agenda item at the next RPM meeting.

Comment 27: Section 3.2.3 Lower Aquifer, Basewide

Please include a reference to a figure that shows the location of well, RZ-03.

Comment 28: Section 3.2.4 Groundwater Elevation Trend Analysis

Include a discussion of the criteria used to select wells for trend analysis.

Comment 29: Section 3.2.4.1 Upper Aquifer, Operable Unit 1 Area

The features, "NPP" and "arroyo," should be described and a reference to an AMR figure that shows their locations should be included.

Comment 30: Section 3.2.4.4 Upper Aquifer, Non-CERCLA Sites Area

Discuss the influence of the City of Adelanto percolation ponds on groundwater levels at ZZ051 and the flightline sites.

Comments on Section 4, Operable Unit 1 Site CG070

Comment 31: Section 4 Operable Unit 1 Site CG070

The evaluation and conclusions regarding MNA at this site should be deleted from Section 4 for the following reasons.

- MNA as the sole remedy for this site has been rejected by the regulators (Joint EPA/Water Board letter dated March 30, 2017, and Water Board letters dated February 24, 2017, September 28, 2016, August 5, 2016, January 8, 2016, August 10, 2015, May 13, 2015, December 11, 2014, and March 21, 2014).
- MNA is not part of the current ROD and there is no approved monitoring program for MNA. The current monitoring program is inadequate to evaluate MNA (see Enclosure 2, items 2.1.3 and 2.3.
- Water Board staff have determined the Air Force's supporting evaluations of MNA at this site are technically flawed (see Enclosures 2 through 4).

Also see Comments 3 and 12.

Comment 32: Section 4.1 Site Setting and History

The statement that VVWRA is the source of all nitrate in the Lower Aquifer is unsupported and inconsistent with historical data that show the nitrate release from the Air Force's sewage treatment plant (STP) impacted both the Upper and Lower Aquifers. The text states the conclusion that Lower Aquifer nitrate plume is from VVWRA is based on data provided by VVWRA, but the supporting data are not included in the AMR. See Comment 3 requesting removal of unsupported statements from AMRs.

Historically, VVWRA has discharged effluent with nitrate concentrations above the maximum contaminant level (MCL) to its ponds and elevated concentrations of nitrate are present in the vicinity of the VVWRA ponds. VVWRA's *2017 Annual Groundwater Monitoring Report, Percolation Ponds and Biosolids Waste Unit*s shows that nitrate concentrations in the vicinity of its ponds are below the primary MCL of 10 milligrams/liter (mg/L) (Water Board staff can provide this report for the Air Force's reference).

VVWRA's nitrate contribution does not negate the continued presence of nitrate plumes in the Upper and Lower Aquifers that originated from the STP ponds. The discussion of nitrate in groundwater should be revised to describe the nitrate plumes and correctly attribute the source of the nitrate in the vicinity of the STP to those ponds (also see Comment 68). If the Air Force intends to evaluate the source of nitrate in the Lower Aquifer further, Water Board staff would be happy to review a work plan to support that investigation.

Comment 33: Section 4.4.2.1 Upper Aquifer Results

The Focused Feasibility Study for CG070 predicted that the Upper Aquifer plume would discharge to seeps in the drainages in the cliff above the Mojave River. Please describe how the seeps are being monitored for impacts.

Comment 34: Section 4.4.2.2 Lower Aquifer and Flood Plain Aquifer Results

The AMR should be revised to address previously identified data gaps as described in Enclosure 2 items 2.1.3 and 2.3.2, which are included here by reference.

Comment 35: Section 4.4.2.2 Lower Aquifer and Flood Plain Aquifer Results

Well NZ-72 is not adequate to monitor the northern migration of the plume and its threat to the Flood Plain Aquifer. TCE in this well has increased from non-detect in 2013 to 25 micrograms/liter (µg/L) in 2016. The leading edge of the plume (as defined by the 5 µg/L isoconcentration contour) must be delineated. The AMR should report that the plume is expanding in this area and that the leading edge of the plume is a data gap. The Air Force should prepare a work plan that proposes additional monitoring wells in this portion of the plume to delineate lateral extent, monitor plume migration, and evaluate threat to the Flood Plain Aquifer. See Comment 4 regarding identification of data gaps.

Comment 36: Section 4.4.2.2 Lower Aquifer and Flood Plain Aquifer Results

The discussion of EW06 should address the fact that EW06 has a higher concentration of TCE than either of the two adjacent wells with shorter screens, which indicates that EW06's longer screen likely intersects a zone of preferential contaminant migration that is not captured by the shorter screened wells. The Air Force proposed deleting EW06 from the 2017 monitoring event, but this well is providing valuable information and must be kept in the monitoring program. This sampling rationale should be

included in the table of well information that is included with technical memoranda for sampling events. This table should also be included in the AMR for reference.

Comment 37: Section 4.4.2.2 Lower Aquifer and Flood Plain Aquifer Results

Water Board staff have previously rejected the Air Force's contention that TCE detected in the flood plain aquifer wells is from a source other than CG070. See Enclosure 3, Comment 2; which is incorporated by reference. The AMR states TCE occurs upgradient in the Flood Plain Aquifer, but does not include the data to support this statement. See Comment 3 and remove this unsupported statement.

Comment 38: Section 4.4.3 TCE Mass Summary

The discussion of mass loss and decay rates should be deleted from future AMRs since the evaluation of an unaccepted remedy is beyond the scope of the AMR and because this specific evaluation has been rejected by the regulators. The Focused Feasibility Study for CG070 concluded that no significant degradation of TCE is occurring and the Air Force's subsequent attempts to demonstrate degradation have been rejected by the regulators. See Comment 31, Enclosure 2 items Nos. 1.2.3.2.3 and 2.5; Enclosure 3 Comments 13, 14, and 16, which are incorporated here by reference.

Comment 39: Section 4.5 Regulatory Compliance Summary

A September 28, 2016 letter from the Water Board (Enclosure 4) conveyed comments on the 2016 Five-Year Review. The Air Force did not address these comments in the Five-Year Review or provide a response to this letter. Comments 31, 33, 34, 36, and 37 of Enclosure 4 specifically address the Air Force's conclusions regarding the RAOs and are incorporated here by reference. As described in these comments, Water Board staff do not agree with this section's conclusion that four of the five RAO have been achieved. See Comment 6.a regarding obtaining regulatory concurrence on RAO conclusions.

Comment 40: Section 4.6 Summary and Conclusions

Comments 31 through 39 apply to this section and to Section 17.1 under *Summary, Conclusions, and Future Activities*.

Comment 41: New Section 4.7 Recommendations and Planned Activities

Under the new section (see Comment 5) include a discussion of the following.

- The Air Force's agreement to conduct pilot testing of an active remedy for the groundwater plumes (see *Comment* 12) and a schedule for these activities.
- Plans to address data gaps discussed in Comments 33, 34, and 35.
- Sampling of the VVWRA wells for PFOS and PFOA, which are commingled with the TCE plume (see Comment 21).
- Sampling for PFOA and PFOS of the private residential wells east of Shay Road and east of the former wastewater treatment plant (WP026)
- Any other recommendations or planned activity to achieve compliance with the RAOs.

This information should also be summarized in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.1.

Section 5, Operable Unit 5 Site FT019

Comment 42: Section 5.2 Regulatory Framework

This section refers to health screening levels in Table 5-2 that are from 2005. Please explain why these screening levels do not reflect current criteria.

Comment 43: Section 5.3 Changes to Operations, Maintenance, and Monitoring

Include justifications for the continued shut down of SVE systems (see Comment 16).

Comment 44: Section 5.5.2.1 Site FT019a *AND* Section 5.5.2.2 Site FT019c

These sections should be revised to discuss the major constituent of concern (COC) for these sites, i.e., TCE.

Comment 45: Section 5.6. Summary and Conclusions

Comments 43 and 44 apply to this section and to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.1.

Comment 46: Section 5.6.1 Site FT019a Soil Source (under Summary and Conclusions)

Please include a reference to the regulatory-approved report that contains the results of the rebound study that is used as the basis for the conclusions in this section or delete the conclusions (see Comment 3). Also note, it is inappropriate to include new information in a summary and conclusions section.

Comment 47: New Section 5.7 Recommendations and Planned Activities

The following planned actions should be discussed here.

- Restart of the SVE systems, which have been off since 2011 (see Comments 5 and 16).
- Installation of new SVE wells at FT019c.
- Any other recommended or planned actions to achieve compliance with RAOs.

This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.1.

Section 6, OU 3 Site ZZ051

Comment 48: Section 6.1 Site Setting and History

The discussion of COCs for the former jet engine test cells at Site ZZ051 should be revised to state that polycyclic aromatic hydrocarbons (PAHs) are site COCs because they can be generated through the incomplete combustion of petroleum hydrocarbons from jet engine exhaust and have been detected at the site. The AMR should identify the lack of PAH data in shallow soils as a data gap and include the Air Force's plans to address this data gap.

Comment 49: Section 6.1 Site Setting and History

This section concludes that "VI sampling results confirmed that there was no unacceptable human health exposure risk from non-petroleum VOCs…" and that "Results will be formally provided in the Optimization Work Plan being developed for the site." Conclusions that have not yet been

accepted by the regulators, such as this risk assessment conclusion, should not be included in the AMR (see Comment 3).

Comment 50: Section 6-3 Changes to Operations, Maintenance, and Monitoring in 2016

Please explain why the SVE system at Site ZZ051 remains offline after completion of the rebound test in February 2016 (see Comment 16).

Comment 51: Section 6.5.1 Protection of Human Health, *AND* Section 6.5.2 Protection of the Environment

Water Board staff recommend that these sections state that risks from potential PAHs will be evaluated after this data gap is filled.

Comment 52: Section 6.6. Summary and Conclusions

Comments 48 through 51 apply to this section and to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.2.

Comment 53: New Section 6.7. Recommendations and Planned Activities

The following planned activities should be discussed.

- Actions to fill PAH data gap (see Comment 48).
- Submittal of Optimization Work Plan (with results of vapor intrusion investigation) for regulatory review.
- Actions to support site closure.

This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.2.

Section 7, Operable Unit 3 Site OT069

Comment 54: Section 7.1 Site Setting and History

Comment 15 applies to this section's use of the term "inactive" for the soil source, SD025, Industrial Storm Drain.

Comment 55: Section 7.4 Groundwater Monitoring,

The discussion under subheading "Subsite OT069e" should address the adequacy of the groundwater monitoring network as it relates to plume definition and whether the plume is stable or not. As discussed in the BCT meeting on September 7, 2017, the OT069e plume is expanding and there are inadequate groundwater monitoring wells in the downgradient direction to define the plume boundaries. The Air Force has acknowledged the need for additional downgradient wells. However, the discussion in this section, which should be the basis for such decisions, does not acknowledge this data gap. See Comment 4 regarding data gaps and Enclosure 4 Comments 63, 66, 70, 71, 72, 74, 75, 76, and 78, which are incorporated here by reference. The Water Board staff requests that the Air Force meet with the regulators to discuss necessary changes to the monitoring system and the MNA triggers for this site.

Comment 56: Section 7.5 Regulatory Compliance

Water Board staff do not concur with conclusion that natural attenuation is reducing concentrations at OT069e. The plume is expanding and the monitoring system and the MNA triggers are inadequate to

evaluate this site or remedy performance. See Comments 3, 4 and 54 and Enclosure 4 Comments 63, 66, 70, 71, 72, 74, 75, 76, and 78, which are incorporated here by reference.

Comment 57: Section 7.6 Summary and Conclusions

The AMR does not provide any support for the statement that reductive dichlorination cannot occur based on the concentrations of TCE at the site. Reductive dichlorination is documented at sites with lower concentrations than OT069e. Additionally, the statement is inconsistent with AMR's following statement that limited reductive dichlorination may be occurring. Finally, it is inappropriate to introduce new information under Summary and conclusions. See Comment 3 regarding unsupported conclusions and delete the statement that reductive dichlorination cannot occur at this site.

Comment 58: Section 7.6 Summary and Conclusions

Comments 54, 55, and 56 apply here and to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.3.

Comment 59: New Section 7.7 Recommendations and Planned Activities

The new section on recommendations and planned activities (see Comment 5) should include a discussion of the following.

- Actions to address Comments 55 and 56.
- Any other planned actions to achieve the RAOs for this site

This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.3.

Section 8, Operable Unit 3 Landfills

Comment 60: Section 8.1 Site Setting and History

See Comments 10 and 11 regarding inconsistencies between the OU3 ROD and the AMR's discussion of disposal sites.

Comment 61: Section 8.1.1 Sites DP003 and DP004 *AND* Section 8.1.3 Sites LF012, LF014, and LF007

Both of these sections should include references to the document that reports the results of the annual biological inspection.

Comment 62: Section 8.1.3 Sites LF012, LF014, and LF007

It is inappropriate to include the discussion of sites DP033, DP034, SS052, and WP040 under this heading. The nine OU3 disposal sites discussed in this section are part of the SEDA site as defined by the OU3 ROD, not merely a geographic area. For clarity, the nine sites should be discussed under a separate heading and in accordance to the OU3 ROD. See Comments 10 and 11.

Comment 63: Section 8.2 Regulatory Framework

This section should describe the ROD requirements for all landfill sites with remedies specified in the OU3 ROD. See Comment 11.

Comment 64: Section 8.4.1 Landfill Inspection Summary

The justification for not conducting an inspection of LF044 is inadequate. The landfill has a cover and it should be inspected for erosion, exposed waste, etc. Inspections at this site are especially important since it is located in an ephemeral wash less than 0.5 miles upgradient from the Mojave River. See Comment 11 and report inspection results for all disposal sites that have a surface restoration/cover component in the OU3 ROD.

Comment 65: Section 8.4.3.2 Site LF012

Please include a reference to a figure that shows the location of well, NZ-60, and that includes the groundwater elevation contours that demonstrate the wells upgradient location.

Comment 66: Section 8.4.3.2 Site LF012

Please reference the document that reports the evaluation of the total dissolved solid (TDS) fluctuations. If this document has not been accepted by the regulators, the conclusion that the fluctuations are not a result of leakage from the landfill should be deleted from the AMR (see Comment 3). The LTMMP should address the methodology for identifying a release from the site, i.e., detection monitoring in accordance to CCR, title 27, section 20420. Please discuss and apply this methodology. If the LTMMP does not adequately address detection monitoring in accordance to this requirement, the LTMMP should be revised and submitted to the regulators for review and concurrence.

Comment 67: Section 8.4.3.3 Site LF014

This section and following sections incorrectly refer to the primary federal MCL for nitrate, which is 10 mg/L, as a "secondary" MCL. Revise the AMR in this and following sections to specify that 10 mg/L is the primary MCL for nitrate.

Comment 68: Section 8.4.3.3 Site LF014

The reference to a discussion in the 2007 BCT meeting does not adequately support potential contribution of nitrate from the GAFB STP site and the VVWRA ponds. The section does not provide any substantive evidence to demonstrate that the increasing trends are not the result of GAFB sites. Therefore, this unsupported conclusion should be deleted. See Comment 32 regarding nitrate contamination from STP and VVWRA ponds, Comment 3 regarding deletion of unsupported conclusions, and Enclosure 4, Comment 23 regarding nitrate trends.

Comment 69: Section 8.4.3.3 Site LF014

This section states that groundwater data will continue to be collected to determine if the elevated TDS is a result of the landfill or is the result of another source. It is not clear how continued data collection from the existing monitoring network will identify another source. The LTMMP should address the methodology for identifying a release from the site, i.e., detection monitoring in accordance to CCR, title 27, section 20420. Please discuss and apply this methodology. If the LTMMP does not adequately address detection monitoring in accordance to this requirement, the LTMMP should be revised and submitted to the regulators for review and concurrence.

Comment 70: Section 8.4.3.3 Site LF014

See Comments 32 and 68 regarding nitrate source and Enclosure 4 Comment 23 regarding nitrate trends, which is included here by reference.

Comment 71: Section 8.4.3.5 LF007 (Formerly Southeast Disposal Area)

It appears that groundwater in the vicinity of the Parcel K disposal areas has never been analyzed for explosive-related constituents of concerns. Based on the fact that extensive munitions debris was uncovered during recent removal actions at site XU400, an analysis for explosive constituents of concern is warranted. Please include groundwater sampling and analysis for explosive constituents in this area in the next sampling event. The use of the term SEDA in the title of this section should be revised for consistency with the OU3 ROD (see Comment 10).

Comment 72: Section 8.4.2.5 Site LF007 (Formerly Southeast Disposal Area)

The use of the term SEDA in the title of this section should be revised for consistency with the OU3 ROD (see Comment 10).

Comment 73: Section 8.5 Regulatory Compliance Summary

Include a discussion of the landfill RAOs from the OU3 ROD.

Comment 74: Section 8.6 Summary and Conclusions

Comments 59 through 72 apply to this section and to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.4.

Comment 75: Section 8.6 Summary and Conclusions

This section states that no cover repairs are currently recommended for any of the landfill sites. However, not all the landfill sites were inspected (see Comments 11, 60 and 64).

Comment 76: New Section 8.7 Recommendations and Planned Activities

At a minimum, the new section should include upcoming inspections (Comment 75), continued groundwater monitoring, and detection monitoring of TDS at LF012 and LF014 (Comments 66 and 69). This comment also applies to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.2.4.

Section 9 Site Operable Unit 5 FT082 *AND* Section 10 Site Operable Unit 5 SS083

Comment 77: Section 9.5 Regulatory Compliance Summary *AND* Section 10.5 Regulatory Compliance Summary

The RAOs from the 2013 Proposed Plan for Operable Unit 5, which included FT082 and SS083, should be included here, as well as a discussion of the sites' compliance with the RAOs (see Comment 6.b).

Comment 78: Section 9.6 Summary and Conclusions *AND* Section 10.6 Summary and Conclusions

Comment 77 applies to these sections and in the AMR's *Summary, Conclusions, and Future Activities*, Sections 17.3.1 and 17.3.2.

Comment 79: New Sections 9.7 and 10.7 Recommendations and Planned Activities

Planned actions to achieve compliance with RAOs should be described here and in the AMR's *Summary, Conclusions, and Future Activities*, Sections 17.3.1 and 17.3.2.

Section 11.0 Non-CERCLA – Site ST054

Comment 80: Section 11.5 Regulatory Compliance Summary

This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed Comment 7.a, including removal of LNAPL to the maximum extent practicable and successfully demonstrating that the site no longer poses a threat to human health, the environment, and water quality.

Comment 81: Section 11.6 Summary and Conclusions

Comment 80 applies to this section and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.1.

Comment 82: New Section 11.7 Recommendations and Planned Activities

Recommendations and planned actions to achieve compliance with regulatory requirements should be described here and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.1.

Section 12.0 Non-CERCLA – Site ST057

Comment 83: Section 12.5 Regulatory Compliance Summary

Please include a discussion of the draft CAP, which was rejected by Water Board staff in a November 26, 2014 letter, and subsequent discussions between the Air Force and Water Board staff. This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed Comment 7.a, including removal of LNAPL to the maximum extent practicable and successfully demonstrating that the site no longer poses a threat to human health, the environment, and water quality.

Comment 84: Section 12.6 Summary and Conclusions

Comment 83 applies to this section and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.2.

Comment 85: New Section 12.7 Recommendations and Planned Activities

Recommendations and planned actions to achieve compliance with regulatory requirements should be described here and in the AMR's *Summary, Conclusions, and Future Activities*, Sections 17.4.2.

Section 13 Non-CERCLA Site ST067b

Comment 86: Section 13.1 Site Setting and History

Please explain why the referenced report on the 2014 installation of the new SVE and monitoring wells at this site has not been submitted to the Water Board for review and specify when it will be submitted.

Comment 87: Section 13.4.1 Free-Product Distribution

Please describe the procedures used to determine that equilibrium conditions were met in the specified wells.

Comment 88: Section 13.4.7 Groundwater Monitoring

The monitoring wells in the Lower Aquifer are inadequate to evaluate impacts from this site since none of the wells are located downgradient of the source area or the Upper Aquifer plume (groundwater flow

is to the northwest in this portion of the Lower Aquifer). This section should be revised to include a reference to a figure that shows the groundwater elevation contours in the Lower Aquifer. Water quality impacts in the Lower Aquifer should be identified as a data gap.

Comment 89: Section 13.5 Regulatory Compliance

This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed Comment 7.a, including removal of LNAPL to the maximum extent practicable and successfully demonstrating that the site no longer poses a threat to human health, the environment, and water quality.

Comment 90: Section 13.6.3 Groundwater Monitoring (under Summary and Conclusions heading)

Comments 86, 88, and 89 apply to this section and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.3.

Comment 91: New Section 13.7 Recommendations and Planned Activities

Recommendations and planned actions should be included in this new section (see Comment 5). Additionally, Water Board staff do not concur with listed recommendations and find the following actions are necessary at this massive petroleum release site.

- More aggressive free-product removal measures must be implemented to meet the State requirement to remove free product to the maximum extent practicable.
- Evaluate the adequacy of the existing SVE system to remediate vadose zone contamination. See Comment 86.
- Implement actions to aggressively remediate the dissolved plume (Water Board recommends evaluating air sparging with SVE, bioventing, ORC, bio-slurping, or some other method that is more aggressive at remediating the contaminants at this site).
- Evaluate site impacts to the Lower Aquifer.

These actions should be included along with a schedule for their implementation.
This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.3.

Section 14 Non-CERCLA – Site OT071

Comment 92: Section 14.1 Site Setting and History

This section states that "Both infiltration of water from the golf course water storage pond before it was lined, and irrigation of the golf course, created a groundwater mound in the vicinity of well NZ-120 and beneath the golf course" and that the mound is "…expected to persist for some time, as irrigation of the golf course has continued intermittently…" However, the mound is centered on NZ-120 located next to the pond, suggesting that the pond is leaking and is the primary source of infiltrating water. Please explain the basis for the irrigation of the golf course being a significant current source of the mound centered below the pond or revise the text accordingly. Also see Comment 26.

Comment 93: Section 14.3 Changes to Monitoring in 2016

See Comments 21 and 22 regarding sampling Adelanto production wells.

Comment 94: Section 14.5 Regulatory Compliance Summary

This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed Comment 6.b, including successfully demonstrating that the water quality has been restored and the site no longer poses a threat to human health, the environment, and water quality.

Comment 95: Section 14.6 Summary and Conclusions

Comments 92 and 94 apply to this section and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.4.

Comment 96: New Section 14.7 Recommendations and Planned Activities

Water Board staff request that the Air Force include the following under planned activities:

- Request permission to sample the water supply wells located at the private residences east of Shay Road for GAFB groundwater COCs, including volatile organic compounds (VOCs), dieldrin, PFOS, and PFOA (see Comment 21).
- Describe contingency actions to address Comment 22, i.e., alternate means to sample the Adelanto well field if the pump is not replaced in the Adelanto-4 well by the time of the next sampling event.
- Describe actions to achieve regulatory compliance (see Comment 94).

This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.4.

15.0 Non-CERCLA – Site SS084

Comment 97: Section 15.0 Site SS084

This section states that the Air Force requested closure for this site under the State Water Resources Control Board's Low-Threat UST Case Closure Policy. The 2017 AMR should state that site closure was rejected by Water Board staff in a letter dated April 17, 2017 because it did not meet the Policy's criteria for closure.

Comment 98: Section 15.3 Changes to Operation, Maintenance, and Monitoring in 2016.

See Comment 16 regarding the continued shut down of the system. The 2017 AMR should describe what steps were made in 2017 to address the required actions included in Water Board staff's April 2017 letter, including resumption of the SVE and the free-product removal.

Comment 99: Section 15.5 Regulatory Compliance Summary

This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed in Comment 7.a, including removing LNAPL to the maximum extent practicable and successfully demonstrating that the site no longer poses a threat to human health, the environment, and water quality.

Comment 100: Section 15.6 Summary and Conclusions

Comments 97, 98, and 99 apply to this section and in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.5.

Comment 101: New Section 15.7 Recommendations and Planned Actions

The new section should include planned actions to fulfill the required actions stated in Water Board staff April 2017 letter, including resuming LNAPL removal and operation of the SVE system. This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.5.

Section 16.0 Non-CERCLA – Site SS030

Comment 102: Section 16.4.1 Free-Product Distribution

Since the LNAPL thicknesses are related to water level, changes in water level should be provided along with the product thicknesses. Please provide summary tables with the data in the text and provide field data sheets in appendices.

Comment 103: Section 16.5 Regulatory Compliance Summary

This section should acknowledge that the Air Force will not achieve regulatory compliance until it satisfies the requirements listed Comment 7.a, including removing LNAPL to the maximum extent practicable and successfully demonstrating groundwater quality has been restored and the site no longer poses a threat to human health, the environment, and water quality.

Comment 104: Section 16.6 Summary and Conclusions

Comment 103 applies to this section and to the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.6.

Comment 105: New Section 16.7 Recommendations and Planned Activities

This new section should describe planned actions to obtain compliance with regulatory requirements. This information should also be included in the AMR's *Summary, Conclusions, and Future Activities*, Section 17.4.6.

Section 17, Summary, Conclusions, and Future Activities

Comment 106: Section 17

The site specific sections in Section 17 do not adequately describe future activities (see Comment 5).

Section 18 References

Comment 107: Inclusion of Draft and Draft Final Documents

Water Board staff do not concur with the inclusion of draft and draft final documents since they have not received regulatory concurrence and are not available to the public. Some of these documents have not been finalized because the regulators are disputing the documents. Additionally, inclusions of non-final documents can be misconstrued, especially in cases where the version (e.g., draft, draft final, or final) is not specified. For example, the list of references includes a ROD amendment for LF044 that does not specify the version. However, the ROD amendment has not been finalized or approved. Please do not include references to non-final documents in future AMRs, with the exception of the QAPP. Please continue to reference the QAPP.

Finally, documents that were rejected by the regulators should not be included in the references, even though they are titled "Final." For example, CB&I Federal Services, 2016c, Final Technical

Memorandum, Evidence of Natural Attenuation Site CG070. The Water Board rejected the document due it many inappropriate and unsupported conclusions (Enclosure 2).

Comment 108: Administrative Record

Please include administrative record numbers for each document.

You may contact me at (530) 542-5471 (linda.stone@waterboards.ca.gov), Todd Battey, Engineering Geologist, at (760) 241-7340 (todd.battey@waterboards.ca.gov), or William Muir, Engineering Geologist, at (760) 241-3523 (william.muir@waterboards.ca.gov), if you have any questions regarding this letter.

Linda Stone

Linda Stone PG, CHG
Engineering Geologist

Enclosures:

1. Memorandum from Alice Campbell to Linda Stone, dated February ?, 2018,
2. Letter from Lauri Kemper, Water Board to Phil Mook, Air Force, dated February 24, 2017.
3. Letter from Linda Stone, Water Board to Don Gronstal, Air Force, dated August 10, 2015
4. Letter from Linda Stone, Water Board to Don Gronstal, Air Force, dated October 5, 2016.

cc: Phil Mook, BRAC AFCEC
Mary Aycock, USEPA, Region IX
Indira Balkissoon, Tech Law
Alice Campbell, DTSC/GSU
Kimberly Gettmann, DTSC HERO
Anna Garcia, Mojave Water Agency
Calvin Cox, SPS
Tarek Ladaa, Aptim
David Daftary, Aptim
Mark Thomas, Aptim
Keith Metzler, City of Victorville, SCLA
Eric Ray, City of Victorville, SCLA
Steve Ashton, City of Victorville, Public Works
Logan Olds, VVWRA
Gabriel Elliott, City of Adelanto City Manager
Brian Wolfe, City of Adelanto Engineer
Dave Kachelski, City of Adelanto WWTP Director of Operations
David Dittemore, Victorville Correction Complex

LSt/gg/T: GAFB 2016 AMR WB com LS TFB_BM
File Under: GeoTracker

Department of Toxic Substances Control

Matthew Rodriquez
Secretary for
Environmental Protection

Barbara Lee
Director
9211 Oakdale Avenue
Chatsworth, California 91311

Edmund G. Brown Jr.
Governor

MEMORANDUM

TO: Ms Linda Stone, PG, CHg
Engineering Geologist
Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd
South Lake Tahoe, CA 96150

FROM: Alice Campbell, PG, CEG, CHg
Senior Engineering Geologist
Chatsworth Geological Services Unit

REVIEWED: Craig Christmann, P.G.
Senior Engineering Geologist
Chatsworth Geological Services Unit

DATE: January 9, 2018

SUBJECT: 2016 Basewide Annual Monitoring and Operations Report for CERCLA and Non-CERCLA sites, by CB&I Federal Services LLC, for Former George Air Force Base, Victorville, California, Dated June, 2017.

PCA: 14718 Site Code: 400071-47 Work Request No.20025728

Introduction:

At your request, Chatsworth Geological Services Unit (GSU) staff has reviewed the 2016 Basewide Annual Monitoring and Operations Report described above and dated June, 2017. This review covers hydrogeology and hydrolgeologic data analysis.

Matthew Rodriquez
Secretary for
Environmental Protection

Department of Toxic Substances Control

Barbara Lee
Director
9211 Oakdale Avenue
Chatsworth, California 91311

Edmund G. Brown Jr.
Governor

MEMORANDUM

TO: Ms Linda Stone, PG, CHg
Engineering Geologist
Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd
South Lake Tahoe, CA 96150

FROM: Alice Campbell, PG, CEG, CHg
Senior Engineering Geologist
Chatsworth Geological Services Unit

REVIEWED: Craig Christmann, P.G.
Senior Engineering Geologist
Chatsworth Geological Services Unit

DATE: January 9, 2018

SUBJECT: 2016 Basewide Annual Monitoring and Operations Report for CERCLA and Non-CERCLA sites, by CB&I Federal Services LLC, for Former George Air Force Base, Victorville, California, Dated June, 2017.

PCA: 14718 Site Code: 400071-47 Work Request No.20025728

Introduction:

At your request, Chatsworth Geological Services Unit (GSU) staff has reviewed the 2016 Basewide Annual Monitoring and Operations Report described above and dated June, 2017. This review covers hydrogeology and hydrolgeologic data analysis.

Comments.

1. Section 1.6, Hydrogeology. The summary is hard to understand and is missing some information crucial to understanding groundwater flow at the site. Suggested revision:

Groundwater movement, recharge, and discharge in the vicinity of the former GAFB is controlled by both the site's stratigraphy, and by natural and artificial sources of recharge. The aquifer consists of an ascending sequence of flat-lying fluvial, lake, lake margin, and alluvial-fan sediments. Internally, these sediments have typical lateral facies changes from coarse to fine over short distances, making correlations between boreholes difficult. The sequence has been divided into the following layers:

--An Upper fluvial unit, containing the Upper Aquifer (UA), consisting of silty sands and occasional gravel stringers.
--A lacustrine unit called the Middle Lacustrine Unit (MLU), a former desert lake that extends beneath the base but with a shoreline at about the eastern base boundary. The shoreline facies, called the Permeable Lacustrine Zone (PLZ) is coarser, and allows water perched in and above the lacustrine unit to drain down and to the east, or northeast in the northern part of the base.
--A lower fluvial unit, much coarser than the Upper fluvial unit and including cobble stringers, called the Lower Aquifer. The top of the Lower fluvial unit is not saturated, and forms an intermediate vadose zone between the MLU and the Lower Aquifer.
--The floodplain of the Mojave River, called the Floodplain Aquifer (FPA), which is even coarser than the Lower Aquifer. Beneath both the Lower Aquifer and the FPA is a deep aquifer that is used for local water supply.

Recharge to the system is mainly from above, and consists of natural recharge from rainfall, areal recharge of applied water, including ball fields and a golf course, water system leaks, recharge from artificial ponds located on the Base and on terraces west of the Mojave River, and a line of recharge beneath the unlined runway drain. Under undeveloped conditions, groundwater in the UA would drain easterly off the edge of the MLU to the Lower Aquifer, or flow northeasterly to the Mojave River parallel to the runway drain and discharging to the Mojave River. The Mojave River itself can be either a gaining or losing stream, so the Lower Aquifer can either receive water from the river, or contribute base flow to it, depending on which of the levels is higher at the time. However, other water sources have been added by development of the Base and surrounding land, so groundwater mounds located beneath artificial ponds steer groundwater near these mounds, and create local vertical gradients. Mounds are associated with both base activities and nearby water treatment plant operations both

east and west of the Base. When the ponds are not being used, the mounds collapse, and groundwater flow reverts to its undisturbed pattern.

2. Section 3.2, Groundwater elevations. General comment. As described above, both horizontal and vertical gradients are present in the aquifer system. When vertical gradients are present, monitoring well screen lengths and the screen's vertical position in the aquifer affect the groundwater elevation measurement. Contour maps assume no vertical gradient, and that the contours represent a vertical surface. Two wells screened at different vertical intervals will give different elevations, and cause wrinkles or wobbly lines in a contour map. Wells used for contouring need to have similar screen settings, and have similar screen lengths, because head in a well is the average of the head across the wetted screen. The head in a 100-foot screened well does not measure the same thing as head in a 20-foot screened well. In general, at George AFB, contours should include wells over a vertical band no more than about 30-50 feet thick. For example, NZ-100's midscreen point is 2616 MSL and head is 2600.76, and NZ-112's midscreen is 2585 MSL and 2016 head is 2602.38, so they are nearly 30 feet apart vertically, and head in 2016 was two feet different. They create a wrinkle when contoured together. The Upper Aquifer is too thick to be contoured as one unit, and it needs to be separated into thinner layers and have long-screened wells removed from the contour dataset. Similarly, the MLU can be divided into 2 or 3 different parallel layers, which reduces the irregularities in the contour maps without very much guesswork about whether to include or exclude a well from the group being contoured.

3. The Lower Aquifer is also too thick to be contoured as a single layer. Figures 1 to 5 attached below show how separating the Lower Aquifer into two parts makes believable contours without having to exclude any but long-screen wells. Separating out wells by the position of the screen is worthwhile and eliminates misleading contour patterns being caused by vertical gradients.

4. Section 3.2.3, Lower Aquifer, Basewide. Our TIN contour maps do not support the report's statement that a groundwater discontinuity exists parallel to the Mojave River south of the VWRA ponds. The contours seem to follow topography towards the river, and there is a mound at the mouth of the runway drain. The simplest way to detect a no-flow boundary is to make a TIN map and look to see whether the ends of the contours along the Mojave River intersect the river at a right angle. (See attached Figures 6 and 7.) None of the years checked showed this pattern in either the L1 or L2 zone. In OU1, the contours are at approximately 45 degrees to the river. In the south half of GAFB near NZ-64, the L1 contours also are at about 45 degrees to the river. Further south,

in L2 near MW-148, water levels are controlled by the mound which has drained off the Upper Aquifer in this area. See figures 5 and 6, below. The statement should be substantiated with newer data or removed.

5. The Lower aquifer well screens span over 100 ft of the layer, and heads from top to bottom of this zone can differ substantially, for example, at NZ-131abc, there is about ten feet of head difference between the three screened intervals which span 100 feet. The Lower Aquifer wells should be separated into two groups, those within 50 feet of the top of the aquifer, and those within 50 feet of the bottom. No wells with screens longer than 30 feet, or which cross into the other zone, should be used for contouring. Figure 3-6 from the monitoring report uses wells with screens chosen throughout the lower zone, and there is no obvious or rigorous pattern in how the wells were selected. Figures 1 and 2, below, show how much smoother the Lower Aquifer contours are when the wells are divided between the upper and lower half of the aquifer. Similar results occur for the Upper aquifer and the MLU, except that a few wells still contour with a different, generally lower, layer, which could be related to details of boring backfill or nearby long-screened wells. Groundwater flow contours and directions would be more accurate if the wells are selected from a vertically restricted range without long-screen wells.

6. Section 3.2.4.3. It is not clear whether the High Desert Power Plant's usage of reclaimed water is increasing, or whether most of the water pumped up to the plant is being lost during transmission. Knowing where the water is metered would help to understand whether water is lost before or after being metered. If their meter is before the storage tower by the golf course, then the Power Plant may be relying on faulty water use information. If the leak in the pond by the water tower is fixed, the salvaged water would go to the High Desert Power Plant, and the ponds may still be needed. Until the leak by the tower is fixed, it is too early to say the ponds will go out of service soon.

7. The contour maps are important tools for assessing the movement of contamination, and to be useful, they need to honor the original data as closely as possible, and well inclusion should adhere to physically-based rules. Because gravity is the prime mover for groundwater, elevation of the screens and use of the mid-screen elevation should be the main factors in well selection, along with the length of the screen and proximity to long-screened wells.

8. Section 4.4.2.1 Upper Aquifer TCE. There are several ways to explain the decrease in concentration of TCE at NZ-55, NZ-82, and NZ-83. These include changes in flow direction directing the plume away from the wells, the plume descending out of the M1 layer into the M2 layer, and dilution of the plume with

fresh water. A contour map of the upper MLU (M1) for 2004 is attached as Figure 8, and can be compared with the 2016 M1 contours (Figure 9), 2016 middle MLU (M2) contours, and 2016 Upper Lower Aquifer (L1) contours. The first point to observe is that for both years, the three wells were in an area of east-northeast flow, but at the very edge of the M1 part of the MLU. Figure 9 shows flow in the M2 zone, and wells NZ-53 and NZ-54 have high concentrations of TCE, which evidently has drained to them from the M1 zone. Finally, Figure 10 shows the upper part of the Lower Aquifer, and shows high TCE concentrations downgradient of the three wells in the M1 unit. The groundwater contour evidence shows that the 'attenuation' consists of contaminants flowing off the MLU edge and landing on the upper part of the Lower Aquifer. NZ-52 has high nitrate, and the water there likely originated near the STP ponds. The distribution of PCE also matches this flow pattern. The section should be revised or removed.

9. Section 4.4.2.2, first bullet. Well NZ-72 is at the northeast leading edge of the plume. The 2010 particle tracks (Figure 11) show that NZ-48 was generally upgradient of NZ-72. Flow in the Lower Aquifer is locally dominated by mounds beneath the VVWRA ponds and the runway drain, and the contaminated water now at NZ-72 appears to have originated near the runway drain, but was pushed North and will eventually be replaced by mounded recharged water. Water draining the Upper Aquifer has TCE, and is therefore not now reaching NZ-48, which is now upgradient of NZ-72. Groundwater in the lower zone upgradient of NZ-72 swings clockwise around the pond complex to reach the river east and north of the VVWRA treatment plant. The mounding from the ponds appears to be the main driver of both horizontal and vertical gradients, as well as the mechanism for reduced concentrations of TCE in wells near the mound, and this should be mentioned in the section.

10. Section 4.4.2.2, second bullet. The following table compares the three wells:

Well	Scrn.Top	Scrn.Bot	WSE 2015	WSE 2016	TCE 2015	TEC 2016
EW-06	160	230	2601.4	2603.91	51	76
NZ-138	130	150	2604.57	2606.99	26	34
NZ-139	225	235	2603.39	2605.79	0	0

NZ-138 is a little shallower than EW-06, so its smaller TCE concentrations can be understood as it just misses a zone with higher TCE screened in EW-06. NZ-139 screened just below EW-06 would likely detect TCE if there was a downward gradient between it and EW-06, but EW-06's head is lower, so there is an upward gradient between NZ-139 and EW-06. However, there is a downward hydraulic gradient from NZ-138 to EW-06, consistent with the TCE concentrations. The VVWRA ponds are likely the source of the higher heads in

the newer wells. The section should discuss the effects of vertical hydraulic head on the distribution of TCE.

11. Section 4.4.2.2, third bullet. See Comment 9. The following table compares these wells, and shows a consistent downward gradient in the Lower Aquifer.

Well	Scrn.Top	Scrn.Bot	WSE 2015	WSE 2016	TCE 2015	TEC 2016
NZ-107	258	278	2602.2	2602.83	94	100
NZ-84	241	256	2601.02	2602.36	75	63
NZ-129b	290	310	2603.67	2605.95	3.4	1.7
NZ-129c	320	340	2603.69	2606.02	5.1	0.91

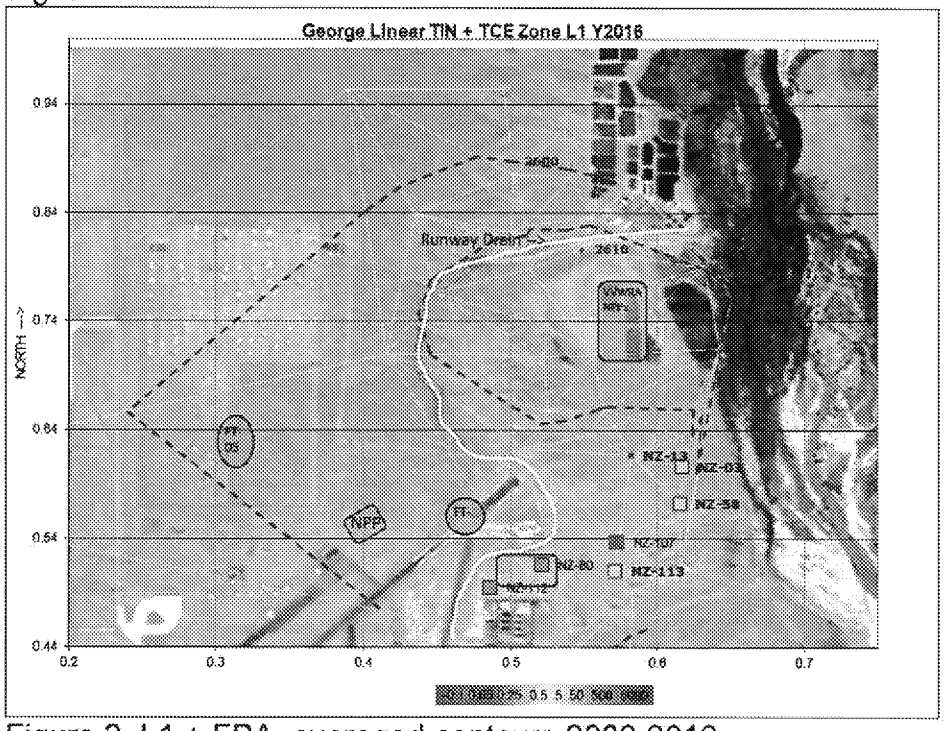
The results are similar to those in the previous comment. Vertical hydraulic head appears to be a factor in TCE distribution in this area also. Neither NZ-129b nor NZ-129c are downgradient of the two shallower wells, but are instead in the lower part of the Lower Aquifer. There does not appear to be a downgradient well in the upper half of the Lower Aquifer east of the FT-082 area. However, NZ-03 is downgradient of NZ-56, and had a low hit of PCE and has continuous low detections of TCE and low detections of nitrate.

12. Section 4.4.2.2, last line. It is not clear where the 'upgradient' FPA wells with TCE detections are located. However, the 131a/b/c cluster has also had TCE detections. NZ-72 is upgradient/crossgradient of the NZ-131 cluster and OW-6. Under the current flow system, dominated by mounding in the VVWRA ponds; groundwater in the lower zone near NZ-72 can swing clockwise around the pond complex to reach the river east and north of the VVWRA treatment plant.

13. Section 4.6- As described above, groundwater flow at George is directed by artificial water mounds from ponds and leaks. Flow directions changed during pumping of the GETS and use of percolation ponds and the runway drain to dispose of treated water, then changed again when the new VVWRA ponds were built. Figures 12 (2010), 13 (2014), and 14 (2016) show changes in flow direction over the last 16 years in the Lower Aquifer. The latest changes are driven by infiltration at the Adelanto ponds west of George. The lower aquifer change eastward to westward flow beneath OU1 occurred after the VVWRA ponds began operation. Shifts in recharge mounds have moved the plumes, and changed the relationship between plumes and monitoring wells. As described above, some plumes have shifted away from some wells, and although concentrations have declined, this does not amount to attenuation because plumes have shifted to affect other wells where concentration levels have increased. Because of the plume movements, time series plots have limited usefulness unless flow directions are explicitly accounted for.

A spreadsheet with zone assignments and screen interval information is available. Questions regarding this memo should be directed to Ms. Alice Campbell by contacting her at 818-717-6623 or acampbel@dtsc.ca.gov.

Figure 1.



Figures 1 and 2— Upper part of Lower Aquifer, first 2016 contours, then average contours for 2008 to 2016.

Figure 2. L1 + FPA, averaged contours 2008-2016

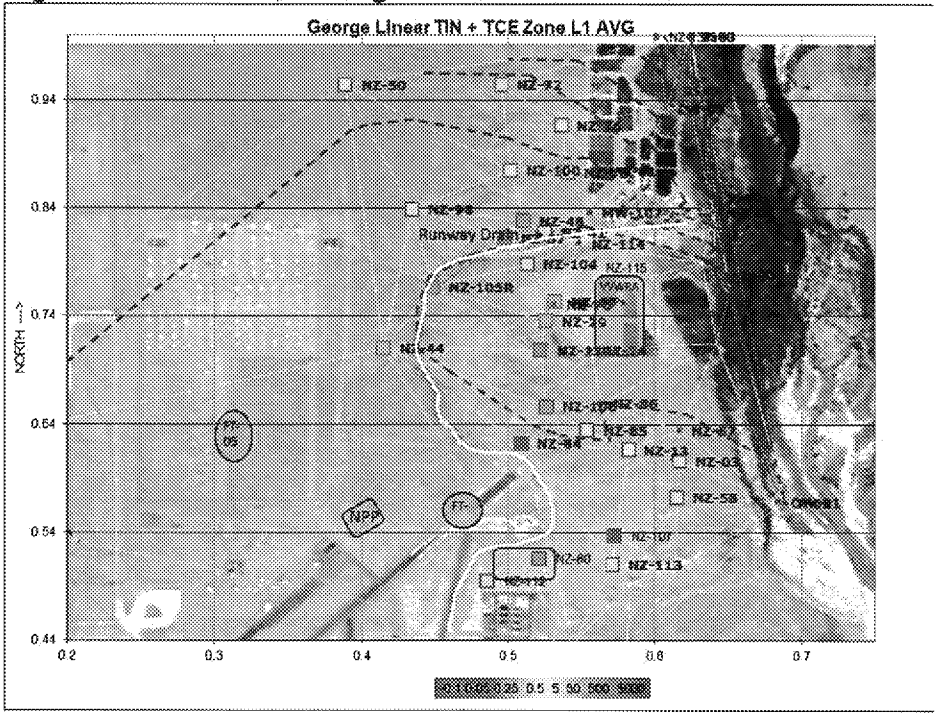
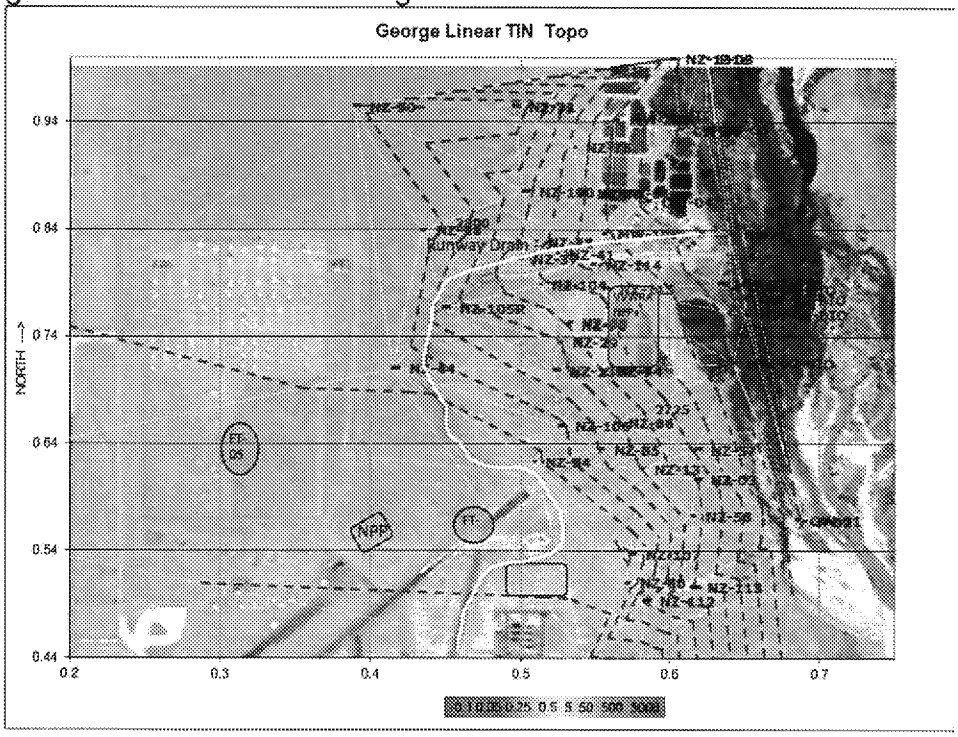
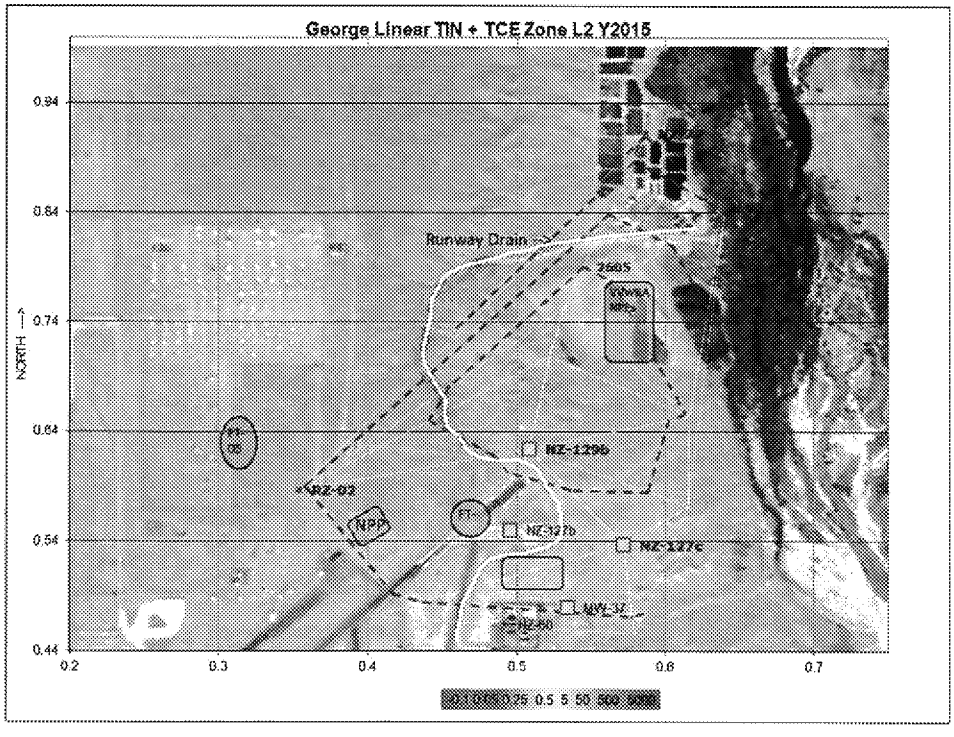


Figure 3. Topography using monitoring well RPs. Note similarity to L1 average groundwater contours on Figure 2.





Figures 4 and 5: Lower part of Lower Aquifer, first 2016 contours, then average contours for 2008 to 2016.

Figure 5. L2+FPA, averaged contours 2008-2016

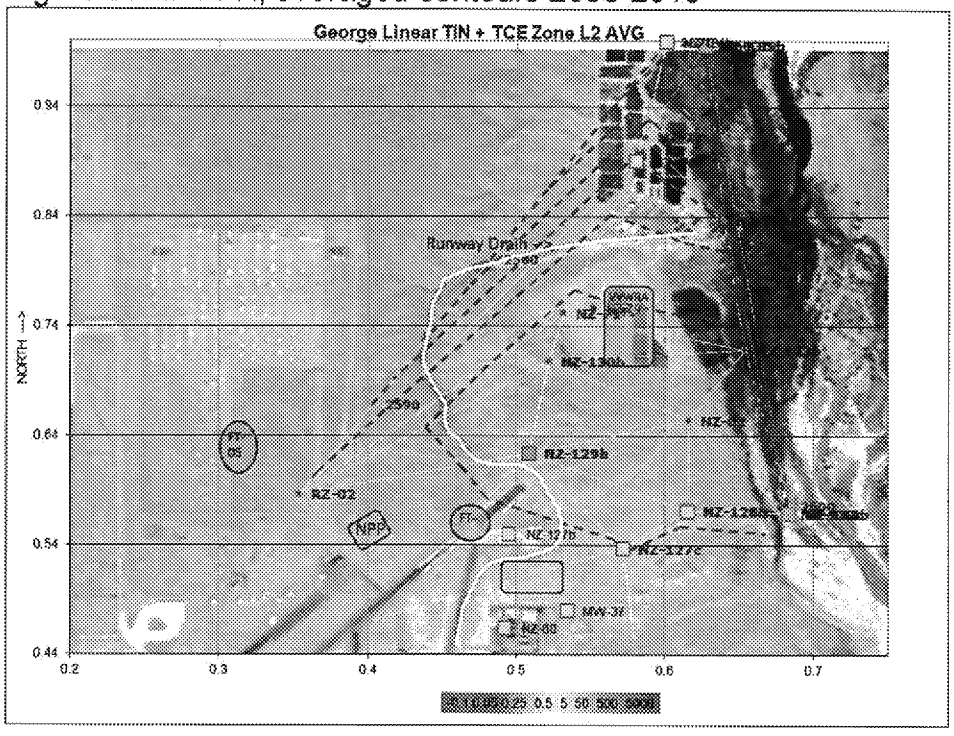
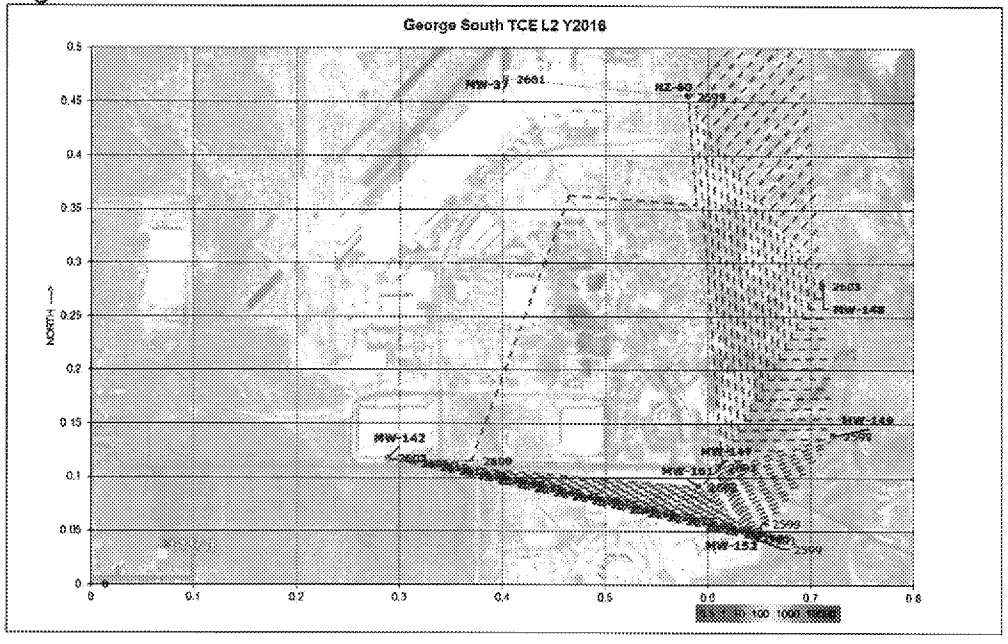


Figure 6.



Figures 6 and 7: 2016 contours on both Upper and Lower part of Lower Aquifer, showing that they do not form right angles at Mojave River.

Figure 7.

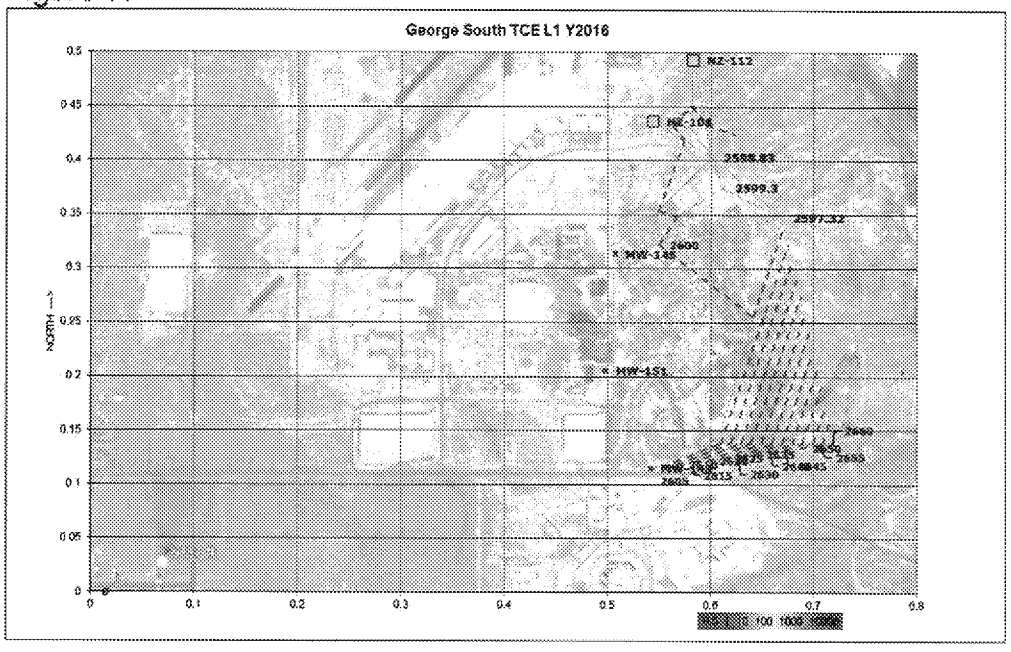


Figure 8. Upper MLU during GETS spreading.

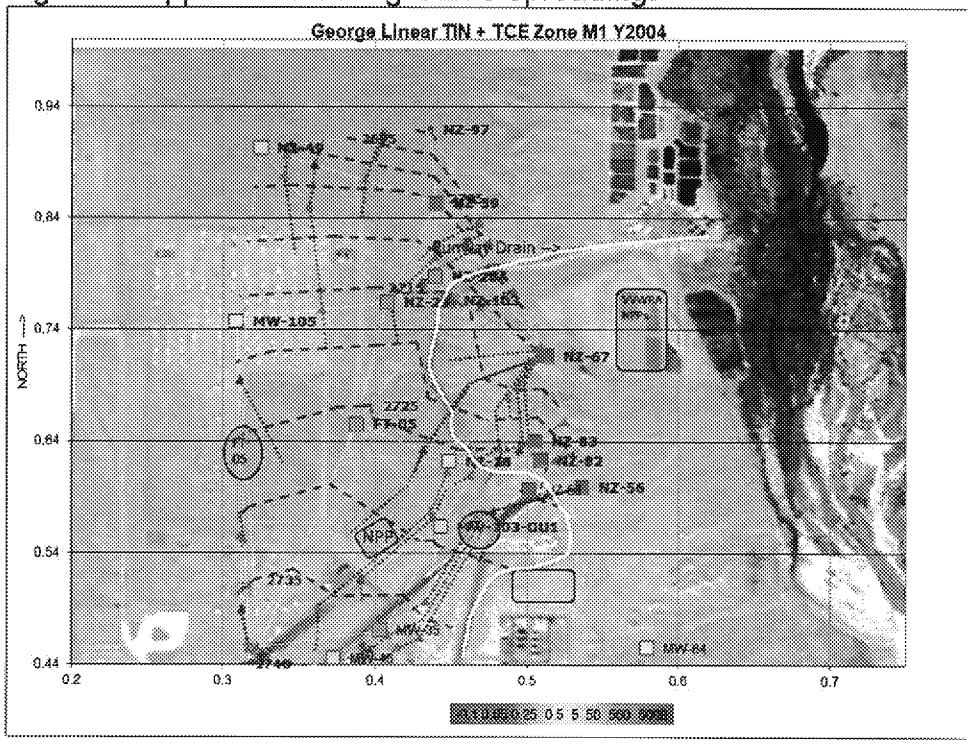


Figure 9. Upper MLU after GETS shutdown to present.

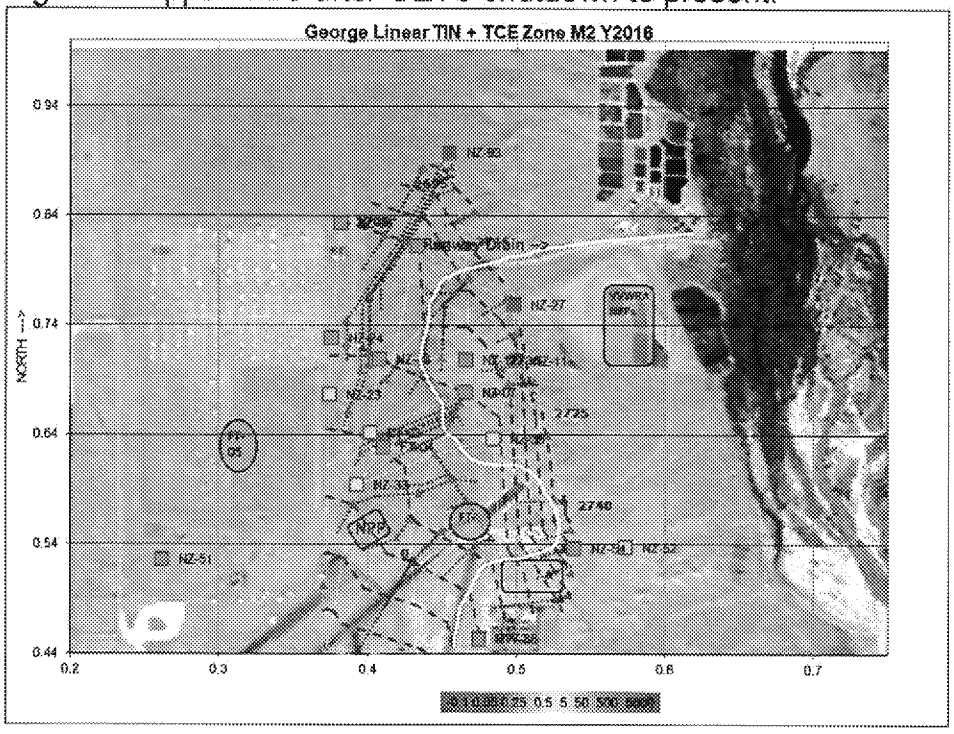


Figure 10. Contours near NZ-72 in upper Lower Aquifer, 2016.

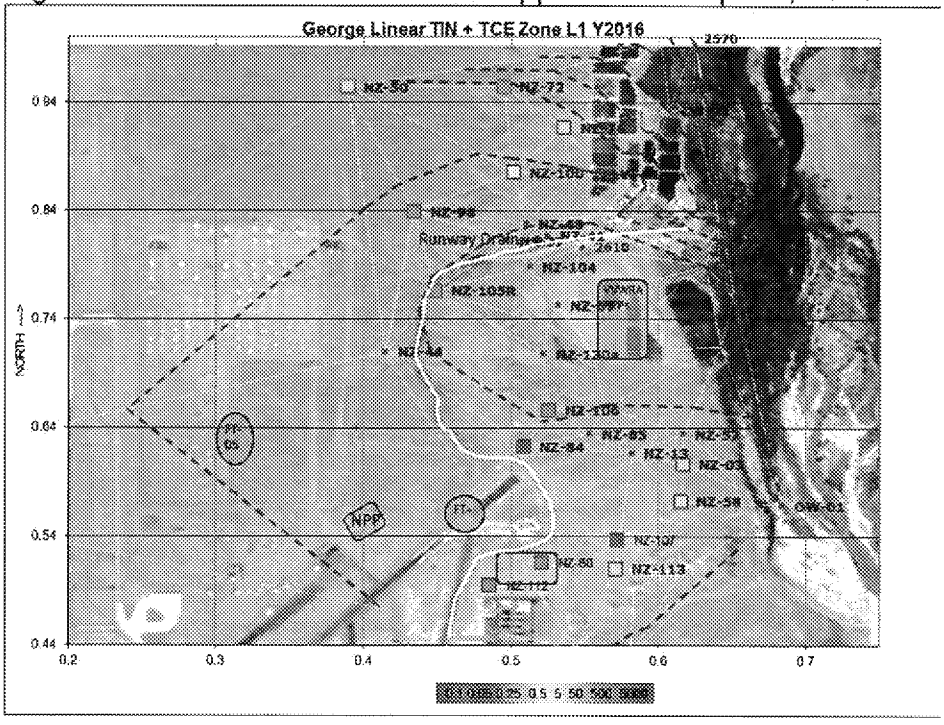


Figure 11. Particle tracks near NZ-72 in upper Lower Aquifer, 2007.

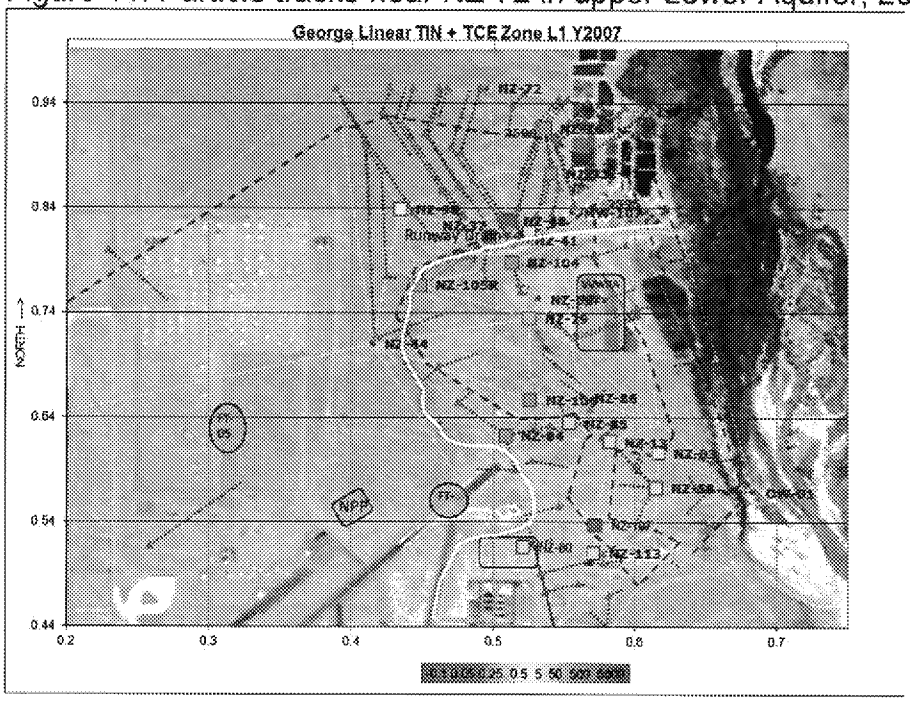


Figure 12, Upper Lower Aquifer contours, 2010, just after GETS.

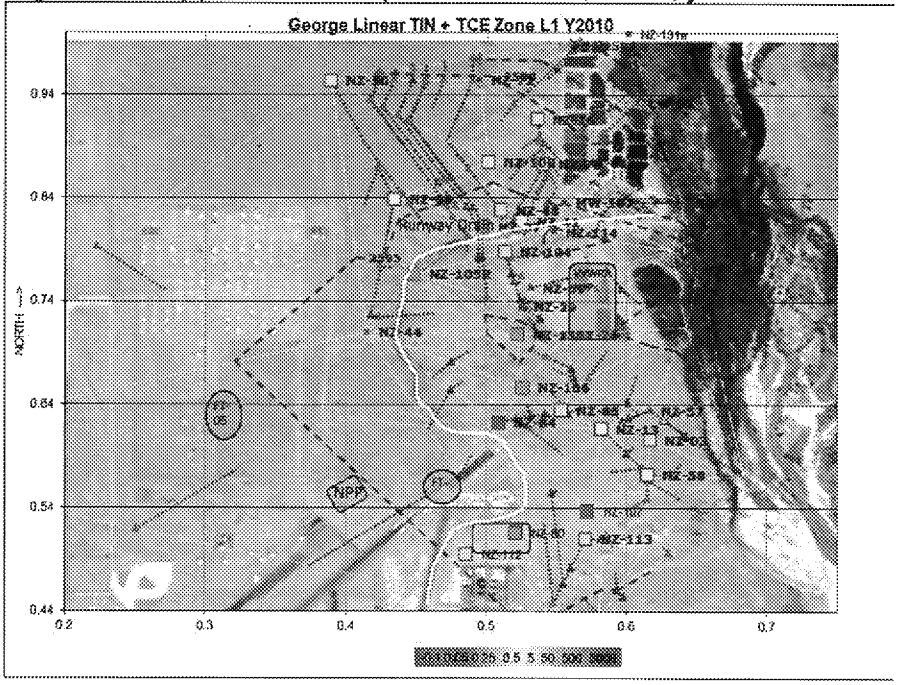


Figure 13, Upper Lower Aquifer contours, 2014, VVWRA spreading.

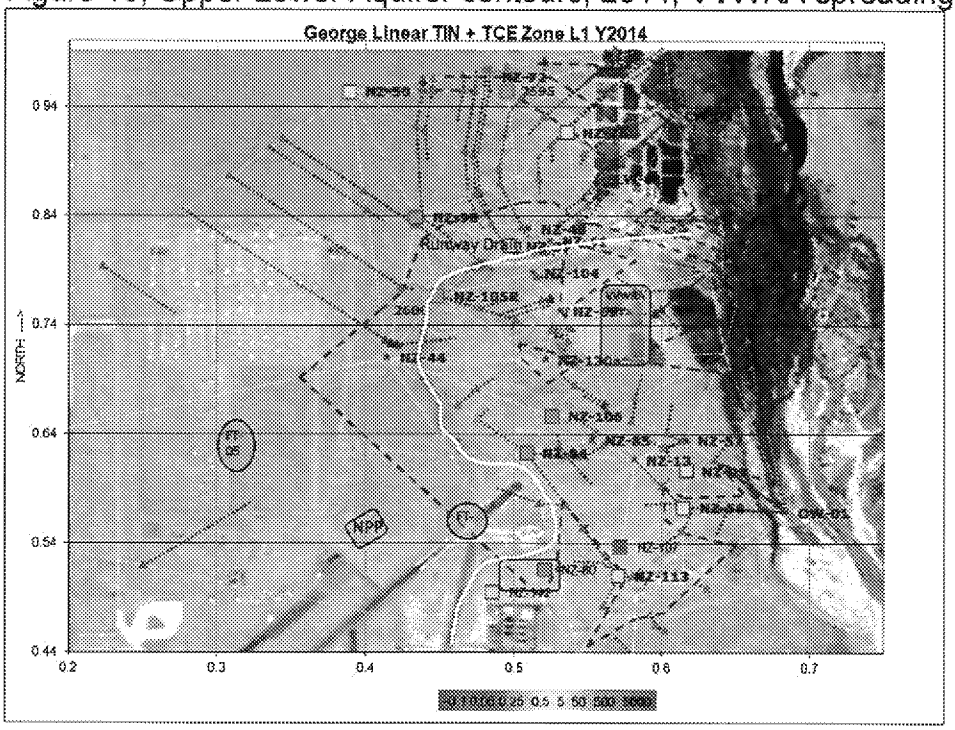
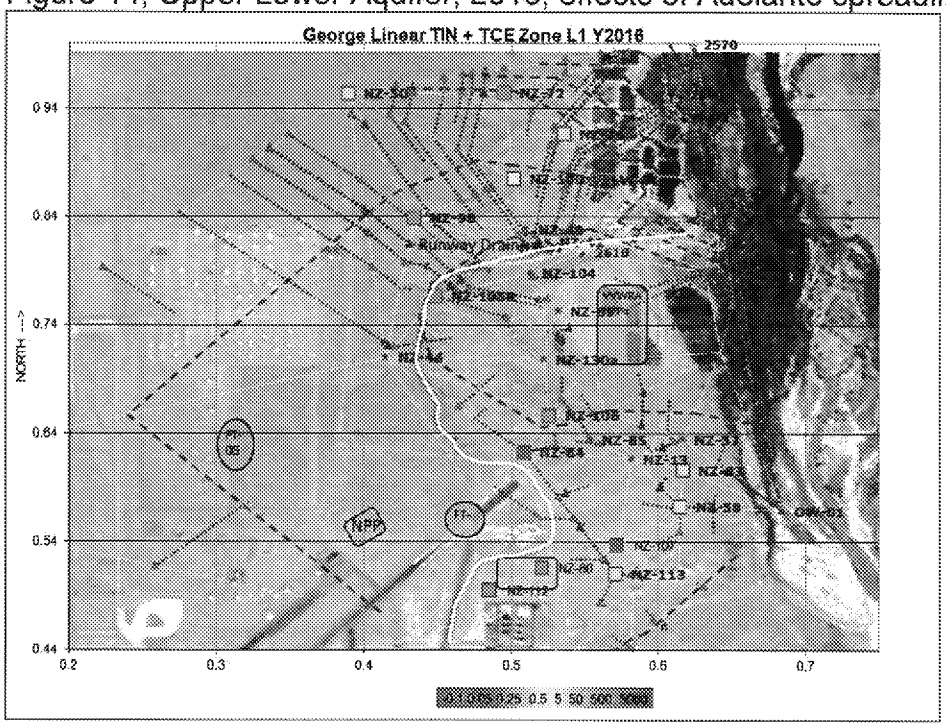


Figure 14, Upper Lower Aquifer, 2016, effects of Adelanto spreading.



February 24, 2017

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Water Board's Non-Concurrence with the Air Force's Proposal to Select Passive Remediation for Groundwater at Site CG070, Operable Unit 1, Former George Air Force Base, Victorville, San Bernardino County

Purpose

In a letter dated August 5, 2016, the Executive Officer of the Lahontan Water Quality Control Board (Water Board) informed the Air Force that active remediation must be implemented at Site CG070 because application of the passive remedy of monitored natural attenuation (MNA) as a sole remedy will not meet regulatory requirements, including restoration of groundwater quality in a reasonable timeframe.

The purpose of this letter is to provide additional technical discussions of why MNA is not adequate to restore water quality at Site CG070 and respond to the *Final Technical Memorandum, Evidence for Natural Attenuation, Site CG070* (Final Tech Memo) and the Air Force's Position Paper both dated May 27, 2016. Based on the information submitted, Water Board finds that the Final Tech Memo does not support the Air Force's position that MNA alone will remediate the contamination in a reasonable timeframe. Additional actions in the form of more aggressive remediation are necessary to address the groundwater contamination of primarily tricholorethene (TCE) that extends over 800 acres, impacts two aquifers, and threatens the Mojave River and its underlying aquifer and supply wells.

Air Force's MNA Position Paper

The Air Force's cover letter for the May submittals states that "Further comments on the use of MNA will be addressed in the Draft ROD Amendment (RODA)," which the Air Force has indicated will put forth MNA with institutional controls as the sole remedial method for CG070. Based on our review of the Final Tech Memo and the monitoring data for the site, there is not an adequate demonstration that MNA meets state and federal requirements; and therefore, the Water Board cannot concur with a future RODA for MNA as the sole remedy at Site CG070.

The Final Tech Memo is a strategic document since it provides the basis for the Air Force's assertion that MNA at CG070 will meet regulatory requirements and restore groundwater in a reasonable timeframe. The Tech Memo is a secondary (supporting) document under the Federal Facilities Agreement for the former George Air Force Base (GAFB) and, as such, is not subject to dispute. However, issues that remain unresolved in the draft final version of the RODA would be subject to dispute.

Initiation of a formal dispute process should only be considered as a last resort. Prior to reaching such a point, the Water Board proposes further engagement between the regulators and the Air Force to resolve outstanding issues at CG070. The Water Board understands that the Air Force has developed an effective process at Kirtland Air Force Base that has promoted collaboration and has been successful in resolving technically challenging issues for a complex groundwater site. Please consider applying a similar innovative and collaborative process to promote remedial progress at GAFB's challenging groundwater sites.

Major Topics

The Final Tech Memo asserts that its findings are based on new information that was not available at the time of the 2012 Focused Feasibility Study (Focused FS) for CG070. However, Water Board's review of the Final Tech Memo finds that its conclusions are based on poorly supported and non-conservative assumptions and methodologies that are inconsistent and contradict critical assumptions and methods of the Focused FS. Consequently, the Water Board cannot accept the Final Tech Memo as the basis for remedy selection.

This letter provides discussions of the following specific topics.

- The need to implement an effective collaborative process to ensure that the remedy selected for CG070 meets regulatory requirements and achieves appropriate remedial goals.
- Technical discussions of the inadequacies of MNA as a sole remedy for CG070 and the need for evaluation and inclusion an active remedial component to restore the beneficial uses of groundwater and comply with regulatory requirements. Specific comments on the Final Tech Memo from the Department of Toxic Substances Control, Geologic Service Unit (GSU) are included as Enclosure 1 and provide further support of the technical discussions.
- Recommended follow-up actions.

Discussion

1. The Collaborative Process and Basis for Selection of a New Remedy

The Final Tech Memo states that a collaborative process was used to develop the Focused FS and that the Proposed Plan was based on the Focused FS. The Water

Board acknowledges the collaborative effort that went into the development of the Focused FS, which included multiple working meetings and an independent consultant's review of the numerical models used to estimate cleanup timeframes. Although the Focused FS evaluated various alternatives, it did not recommend or select a remedy. The regulators accepted the Focused FS as adequate to move the remedial selection process forward even though there were still outstanding concerns (e.g., evaluation of feasibility of achieving background levels), because such concerns were to be addressed at a later time. Unfortunately, the collaborative process has not been applied to remedial selection since completion of the Focused FS and the Air Force continues to go forward with the selection of MNA despite the lack of regulatory acceptance. Problems with the remedial selection process that represent significant impediments to remedial progress at Site CG070 are summarized below.

During development of the Proposed Plan in which the Air Force proposed the selection of MNA, the Water Board informed the Air Force that the estimated cleanup timeframe of 500 years using MNA was not reasonable or acceptable for restoration of beneficial uses of groundwater (Water Board letter dated January 31, 2014). The Water Board and the U.S. Environmental Protection Agency (USEPA) issued technical and process-related comments on the Proposed Plan and objected to the Air Force's issuance of the final version of the document to the public before submitting it to the regulators for review and acceptance (Water Board and USEPA letters, dated March 21, 2014). The regulators also stated that a 500-year MNA remedy at OU1 was too long to be considered a reasonable and acceptable cleanup timeframe.

In the February 2014 public meeting on the Proposed Plan, the Air Force asserted that its proposed remedy of MNA would achieve cleanup goals in a much shorter timeframe (approximately 50 years) than the 500 year timeframe predicted in the Focused FS. However, the supporting data and evaluation had not been provided to the regulators or public for review and comment. The supporting material for the shorter cleanup timeframe was presented to the regulators in preparation for an August 2014 Technical Meeting. At the meeting, Water Board staff informed the Air Force that its calculation of decay rates used to support shorter cleanup timeframes was not technically acceptable. USEPA's August 19, 2014, comment letter on the meeting material also cited problems with the Air Force's calculation of decay rates and their use for predicting cleanup timeframes. The USEPA concluded that the application of these rates would result in an "unrealistic (low concentration) prediction."

In May 2015, the Air Force issued the Draft Tech Memo, which did not address regulators concerns regarding the calculation and use of decay rates. The Draft Tech Memo asserted that it's estimated shorter timeframes were based on "new information" that was not available for the Focused FS, i.e., groundwater data collected since the Focused FS. However, the shorter cleanup timeframes were more directly a function of new assumptions and methods that were inconsistent with assumptions and methods of the Focused FS, and without adequate

justification for these variances from the Focused FS. As a result, the Draft Tech Memo estimated cleanup timeframes were significantly shorter than those estimated by the Focused FS, which were 200 and 500 years, respectively, for the Upper Aquifer and Lower Aquifer. The Draft Tech Memo, in contrast, asserted that it would take 80 years to reach cleanup goals in the Upper Aquifer using MNA and assumed, without technical justification, that it would take the same timeframe for the Lower Aquifer to reach cleanup goals.

In an August 2015 letter, the Water Board provided detailed comments that delineated problems with the Draft Tech Memo, its characterization of the plumes, calculation of decay rates, and estimation of cleanup timeframes. The letter concluded that the use of MNA at CG070 as a sole remedy would not meet Water Board requirements and that additional active remediation was necessary to restore water quality. The Air Force did not engage the Water Board in a comment resolution process.

Nine months later and without discussion or resolution of regulatory comments, the Air Force issued an extensively revised, Final Tech Memo. The Final Tech Memo contained additional new assumptions, methodologies and data interpretations that resulted in an estimated cleanup timeframe for the Upper Aquifer (i.e., 34 years) that was even shorter than the estimated 80 years of the Draft Tech Memo. The Final Tech Memo also estimated a cleanup timeframe for the Lower Aquifer, largely based on a new methodology and unsupported assumptions. Water Board comments on the Draft Tech Memo were not adequately addressed and the Final Tech Memo still included the use of decay rates that the regulators objected to in the August 2014 Technical Meeting and in Water Board's August 2015 letter

The Air Force's approach of not working in good faith to resolve regulatory comments or gain regulatory acceptance on new methods prior to issuance of the Final Tech Memo is not consistent with a collaborative process and is not effective in moving the remedial process forward. Additionally, the Water Board strongly objects to, and rejects, the Air Force's approach to remedial selection, which is based on using vastly different, non-conservative assumptions and methodologies to support the Air Force's preferred remedy of MNA in the Final Tech than were used in the Focused FS to evaluate remedial alternatives. This approach undermines the ability to have a valid comparison of available remedial options, is inconsistent with remedial evaluation and selection requirements of CERCLA, is unacceptable to the Water Board, and does not comply with remedial requirements.

2. Lahontan MNA Report and U.S. Environmental Protection Agency Directive, Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites

The U.S. Environmental Protection Agency (USEPA) Directive, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, 1999 (USEPA MNA Policy), established a framework for the

evaluation and implementation of MNA and included the following statement regarding the use of MNA.

> EPA is confident that MNA will be, at many sites, a reasonable and protective component of a broader remediation strategy. However, EPA believes that there will be many other sites where either the uncertainties are too great or there is a need for a more rapid remediation that will preclude the use of MNA as a stand-alone remedy.

In March 2016, the Water Board adopted the *Final Report on Monitored Natural Attenuation, Evaluation and Application in the Lahontan Region* (Lahontan MNA Report). The report summarizes technical resources on MNA, including the USEPA MNA Policy and discusses specific regional considerations. The Lahontan MNA Report recommends that consideration of MNA as a remedial option should be based on site-specific factors and a regulatory-approved demonstration that the recommended technical criteria have been met. The Air Force has not demonstrated that the following criteria have been achieved at CG070.

2.1. Has the site been adequately characterized for the purposes of an evaluation of MNA?

The Final Tech Memo's overly simplistic characterization of site conditions and plume behavior does not provide an adequate or realistic basis for remedial decisions, especially for the Air Force's proposed reliance on the passive remedy of MNA for hundreds of years. Although a great deal of information on the site has been generated since the 1980s, the Final Tech Memo presents a simplistic portrayal of the hydrogeology and contaminant fate and transport, does not adequately consider relevant information from prior site documents, including the Focused FS and the 2005 Hydrogeologic Conceptual Site Model (Hydrogeologic CSM), and does not acknowledge data gaps and significant uncertainties. Also see Enclosure 1.

The complex site hydrogeology consists of an extensive perched aquifer (Upper Aquifer), a leaky perching zone that pinches out east and north of the site, underlain by a lower vadose zone and the regional aquifer (Lower Aquifer). The history of contaminant releases and migration has been similarly complex. The challenges of relying solely on MNA under these conditions are not adequately considered in the Final Tech Memo.

2.1.1. Upper Aquifer: Site conditions have created a large (700 acres) comingled plume (i.e., TCE plumes from different locations and different periods of release have mixed to form one larger, comingled TCE plume). This comingled plume does not conform to the typical plume configuration making it challenging to evaluate attenuation rates, predict plume behavior, and reduce uncertainties to an acceptable level. Also see Enclosure 1, Comment 36.

2.1.1.1. There are multiple historic source areas, including a very long linear source (i.e., flightline storm drains that discharge to the major arroyo [Arroyo] that in turn discharges to the Mojave River). These sources created individual TCE plumes that mixed, complicating the evaluation

of concentration trends in specific wells. Also see Enclosure 1, Comments 21, 22, 24, 25, and 36.

2.1.1.2. There have been at least two episodes (1980s and 1999) when significant vadose contamination was mobilized, creating large spikes in groundwater contamination. These episodic releases (i.e., pulses) complicate the evaluation of concentration trends in wells. See Discussion Item 2.2.1.1 and Enclosure 1, Comments 19, 20, 22, 23, 29, 32, and 39. Additionally, there appear to be continuous and on-going, low-level releases of contaminants to groundwater as discussed further under Discussion Item 2.2.2.

2.1.1.3. Groundwater flow directions have changed over time causing individual plumes to mix and also contributed to the creation of the large commingled plume. Changes in flow direction affecting plume migration and concentration trends in wells are not adequately considered in the Final Tech Memo. Also see Enclosure 1. In the Upper Aquifer, changes in flow directions have largely been the result of the following factors.

2.1.1.3.1. As discussed in the Focused FS, groundwater flow and plume migration have been altered by the discharge of treated groundwater during operation of the groundwater extraction and treatment system (GETS) under the current Record of Decision for the site. The discharge locations for treated water included the former GAFB sewage treatment plant (STP) ponds, the New Percolation Ponds (constructed for the purpose of infiltrating the GETS discharges), and the Arroyo that drains to the Mojave River. All of these discharge areas overlie the Upper Aquifer plume and correspond or are adjacent to source areas. The discharges influenced plume migration and mixing, and mobilization of vadose zone contamination. The locations and discharge quantities changed over time, causing infiltration and mounding in the underlying groundwater that drove the plumes in different directions over time, and caused fluctuations in TCE concentrations in monitoring wells. See Enclosure 1, Comments 19 and 20.

2.1.1.3.2. Infiltration of precipitation during wet periods may have also influenced groundwater movement at locations where runoff was collected or conveyed (e.g., flightline drains, Arroyo, and percolation basins). Infiltration at these locations may have locally influenced concentration trends in wells by mobilizing contamination, diluting contaminated groundwater, and/or by changing groundwater flow directions. For example, the Hydrogeologic CSM noted that infiltration from the Arroyo contributed to plume displacement in the Upper Aquifer. See Enclosure 1, Comments 16, 19, 20, 40, and 50.

2.1.2. Leaking Perching Zone. At CG070, a leaky perching zone forms the base of the Upper Aquifer. The perching zone consists of lacustrine units, which

are referred to in site documents as the Middle Lacustrine Unit in the western portion of CG070 and the Permeable Lacustrine Unit in the eastern portion. The lacustrine units in the vicinity of CG070 contain fine-grained layers that create four definable saturated layers. The Final Tech Memo does not adequately characterize this zone or consider the impacts of the zone on the performance of MNA. See Enclosure 1, Comments 1, 3, 8 - 10, 12, 13, 26, and 32.

2.1.2.1. Upper Aquifer groundwater migrates vertically to the Lower Aquifer along the eastern and northern edges of the perching zone. This pathway accounts for most of the TCE mass transfer to the Lower Aquifer. See Enclosure 1, Comment 8.

2.1.2.2. The leaky nature of the perching zone creates a strong downward gradient in the Upper Aquifer and TCE also migrates into the Lower Aquifer via preferential pathways within the perching zone. See Enclosure 1, Comment 8.

2.1.2.3. It is highly likely that some of the contaminant mass is retained by the fine-grained sediments of the lacustrine units and that this mass will be slowly released to the Lower Aquifer over a long timeframe. The Focused FS cited the fate and transport of contamination in this zone as a significant model uncertainty that could cause the actual cleanup timeframe in the Lower Aquifer to be longer than predicted by the model.

2.1.3. Lower Aquifer. Site conditions in the Lower Aquifer also make the evaluation of the potential effectiveness and protectiveness of MNA challenging. As in the commingled plume of the Upper Aquifer, the Lower Aquifer does not conform to the typical plume configuration. The complex nature of the Lower Aquifer plume is not adequately characterized or considered in the Final Tech Memo's overly simplistic approach. See Enclosure 1, Comments 7, 11, 14, and 15. The following is a discussion of these factors.

2.1.3.1. The current monitoring network is not adequate to characterize contamination in the Lower Aquifer and the locations and extent of downgradient migration is largely unmonitored. See Discussion Item 2.3.2, regarding the inadequacies of the network.

2.1.3.2. The Lower Aquifer's configuration is, to a large extent, controlled by the migration pathways from the Upper Aquifer over the edge of the perching zone and, to a letter extent, through preferential pathways in the leaking perching zone.

2.1.3.3. The Lower Aquifer is partially a reflection of the complexity of the Upper Aquifer's large, commingled plume, which is the source of the Lower Aquifer contamination and some of the factors that influenced the Upper Aquifer also influenced the Lower Aquifer. For example, the 1999 pulse release of contamination to the Upper Aquifer can be seen in the Lower Aquifer. See Enclosure 1, Comments 18, 32, and 42. '

2.1.3.4. Groundwater flow directions in the Lower Aquifer have changed over time due to changes in the amount and locations of discharges to percolation ponds used by Victor Valley Waste Reclamation Authority (VVWRA), by infiltration of water (i.e., from discharges of GETS treated water and storm water flows during high precipitation events) in the portion of the Arroyo not underlain by the perching zone, and by infiltration from the Mojave River during periods of high precipitation events.

2.1.4. The complexities described above make it difficult to apply simple evaluations such as those used in the Final Tech Memo to predict plume behavior, which is why the Focused FS used the widely accepted U.S. Geological Survey models, i.e., the numerical flow model, MODFLOW-SURFACT, and the transport model, MT3DMS. The Final Tech Memo does not consider these complexities and uses a simplistic regression analysis and projects concentrations from "upgradient" wells. Also see Discussion Item 2.5.

2.2. Are the sources of contamination controlled and no longer contributing or threatening to contribute to groundwater contamination?

The Air Force has not demonstrated that all sources have been remediated to the extent that they no longer are contributing to groundwater contamination and that they do not represent a future threat to groundwater quality.

Source control is a critical issue since it is a primary prerequisite for MNA (USEPA MNA Policy) and any remaining source will significantly lengthen the cleanup timeframe, could cause further plume migration, and will introduce unacceptable uncertainties for the protectiveness of MNA. For example, the 1998 Operable Unit 3 Record of Decision (OU3 ROD) selected MNA for Site OT069e, a TCE groundwater plume south of the flightline. The OU3 ROD estimated it would take 45 years for TCE concentrations to decrease to the maximum contaminant level (MCL) and that the plume would migrate 1,000 feet downgradient over that time. However, no source control measures were implemented until 2006. Recent data shows the plume has migrated approximately 2,000 feet in less than 20 years and concentrations are still increasing at the downgradient portion of the plume. The cleanup timeframe for OT069e is uncertain. This site illustrates general problems with MNA at GAFB and how delays in source control can negatively impact MNA performance, allow plume migration and further degradation of water quality, and significantly increase the cleanup timeframe.

2.2.1. The Final Tech Memo does not adequately support its assertion that additional pulse releases of contamination will not occur in the future. See Discussion Item 2.1.1.2 and Enclosure 1, Comments 19, 20, 22, 23, 29, 32, 39, and 50.

2.2.1.1. The 1999 contaminant pulse was the result of infiltration of treated groundwater discharged to the New Percolation Pond that mobilized contaminant mass in the vadose zone above the Upper Aquifer. The cause of the 1980s pulse has not been evaluated. Without an understanding of the mechanism that triggered the 1980s contaminant

pulse, the Air Force cannot support its assertion that there will never be another pulse-type release.

2.2.1.2. The Final Tech Memo states that institutional controls (ICs) will prevent future infiltrations events that could mobilize contamination. However, there are significant problems and uncertainties regarding reliance on ICs at this large site.

2.2.1.2.1. There is unacceptable level of uncertainty associated with the reliance on questionable ICs over a cleanup timeframe of hundreds of years. The uncertainty is highlighted by prior failures of existing ICs at other GAFB sites (Water Board letter dated December 19, 2014). Additionally, ICs have not prevented infiltration from a City of Victorville pond located at GAFB. Despite a persistent groundwater mound at this location and repeated comments on its potential source from the Water Board, the Air Force did not evaluate potential existing sources. Leakage from this lined pond is continuing unabated and is impacting the pesticide plume (OT071) south of CG070. See Enclosure 1, Comments 40 and 50.

2.2.1.2.2. ICs will not prevent natural episodic infiltration events that influence plume migration, such as infiltration of runoff along the Arroyo.

2.2.2. The Final Tech Memo does not adequately support its statement that source areas are no longer contributing to groundwater contamination. Also see Enclosure 1, Comments 16, 23, 29, 31, 32, 39, and 51.

2.2.2.1. The three monitoring wells that define the southern plume core of the Upper Aquifer, NZ-54, NZ-68, and NZ-51, all show relatively low, but increasing trends. The plume core is centered under the STP ponds, Site WP026, and the former onsite wastewater treatment plant, Site FT020 (current location of the High Desert Power Plant). Further characterization and evaluation are needed to determine the cause of the increasing trends at this location and if source control measures at WP026 or FT020 are necessary. At a minimum, it would be prudent to regrade the STP ponds to prevent infiltration of precipitation and promote sheet flow as the Water Board has previously requested. Also see Enclosure 1, Comments 13, 16, 19 - 22, 24, and 31.

2.2.2.2. Of the six monitoring wells in the vicinity of source area FT019, only the two co-located wells on the north side of the site, FT-05 and FT-02, are in a location that allows them to effectively monitor releases from this site. FT-05, screened in the top portion of the Upper Aquifer, showed a sharp spike in concentration from the 1999 release. Since then, TCE concentrations have returned to the pre-pulse concentrations and have remained relatively stable. These relatively low, pre- and post-pulse concentrations could represent slow, continuous releases from FT019 and indicate that vadose zone contaminant continues to impact groundwater. Although a soil vapor extraction (SVE) system has been in operation at this site and has reduced overall vadose zone

concentrations, it is not clear that it has reached all of the deep vadose contamination. Additionally, some of the contamination may be sequestered in saturated sediments due to a rise in water levels and are not being remediated by the SVE system. See Enclosure 1, Comment 23, 29, 39, and 51.

2.2.2.3. It is more difficult to evaluate concentration trends in the vicinity of source area FT082 because the site has been influenced by infiltration of the STP ponds, the New Percolation Ponds, and the flightline storm drain. These infiltration sources have mobilized and pushed contaminant releases in different directions over time. Although a soil vapor extraction (SVE) system has been in operation at this site and has reduced vadose zone concentrations, it is not clear that it has reached all the deep vadose zone contamination. Additionally, some of the contamination may be sequestered in saturated sediments, due to a rise in water levels, and are not being remediated by the SVE (see Enclosure 1, Comment 23, 29, 39, 51). Additional evaluation of this area is necessary to determine its potential source contribution to groundwater contamination.

2.2.3. It is highly likely that contaminant mass remains in the fine-grained sediments of the lacustrine units and that this contamination will continue to slowly migrate into the Lower Aquifer. The Focused FS considered continued contaminant migration from the lacustrine units as a significant uncertainty that could increase the cleanup times predicted in the Focused FS model. This ongoing source is not adequately considered in the Final Tech Memo.

2.2.4. A recent Air Force study detected the fire retardant compounds, perfluorooctonoic acid (PFOA) and perfluorooctane sulfonate (PFOS), in soil samples at CG070 source areas and in the underlying groundwater, making them contaminants of concern (COCs) for CG070. The extent of PFOA and PFOS in soil and the continuing threat to groundwater have not been determined and represent additional site uncertainties.

2.3. Are the plumes stable or decreasing and is it reasonable to expect the plumes to remain stable or continue decreasing?

Groundwater contamination at CG070 is not stable. The Water Board has major concerns regarding the continued contaminant migration from the Upper Aquifer to the Lower Aquifer and the continued plume migration in the Lower Aquifer that is not being effectively monitored by the existing monitoring network. Problems include inadequate downgradient plume coverage, significant gaps in the coverage, inconsistent screen depths, and inadequate differentiation of wells screened in the Upper Aquifer and those screened in the perching zone. Additionally, the Air Force has not delineated contamination beyond the 5 micrograms/liter (µg/L) isoconcentration contour, and the extent of impacts to groundwater above background conditions (i.e., no detectable concentrations) has not been delineated.

2.3.1. Upper Aquifer Stability. The Water Board accepts that the Air Force has demonstrated that the Upper Aquifer's commingled plume is primarily stable laterally at the MCL for TCE. However, the Final Tech Memo does not address other stability issues, including the following.

2.3.1.1. The perching zone that creates the Upper Aquifer pinches out in the direction of groundwater flow (northeast) and contaminated groundwater in the Upper Aquifer cannot migrate further laterally. This creates an apparent stability, but actually, the groundwater contamination continues to migrate vertical down and into the Lower Aquifer. Based on this continuing contaminant migration into the Lower Aquifer and the increasing TCE trends in the Lower Aquifer, the Upper Aquifer plume cannot be considered to be stable and is acting as a continuing contaminant source to Lower Aquifer. See Enclosure 1, Comment 8.

2.3.1.2. A recent Air Force study found concentrations of PFOS and PFOA in the Upper Aquifer plume were almost two orders of magnitude above the USEPA health advisory. The extent of impacts and stability of these highly mobile and recalcitrant contaminants have not been determined and represent significant uncertainties.

2.3.2. Lower Aquifer Stability. The Lower Aquifer is not stable. Although the existing monitoring network is inadequate to delineate the extent of groundwater impacts, evaluation of the current groundwater flow regime and increasing TCE concentrations in many of the Lower Aquifer wells, show that contamination is migrating away from the monitoring network to the north, west, and south, and is causing further degradation of this water supply aquifer. The Final Tech Memo's assertion that the Lower Aquifer is stable is an erroneous conclusion based on an inadequate monitoring network, misinterpretation of the cause of increasing trends in wells (see Discussion Item 2.3.2.2.4), and failure to adequately consider changes in groundwater flow directions. These factors are discussed below. Also see Enclosure 1, Comment 27.

2.3.2.1. The monitoring network is not adequate to delineate the extent of impacts in the Lower Aquifer under the current flow regime. Prior to VVWRA's use of the southern infiltration ponds in 2001, groundwater flow in the Lower Aquifer was northeasterly, toward the Mojave River. VVWRA's discharge of treated wastewater to the ponds has created an extensive groundwater mound, which drives site groundwater radially to the north, west, and south. Because of this change in flow regime, many formerly downgradient wells are now upgradient and there is inadequate delineation of contamination in the downgradient directions.

2.3.2.2. The four areas of Lower Aquifer groundwater contamination identified in the Final Tech Memo are centered on monitoring wells: NZ-107, NZ-84, EW-6, and NZ-72. These wells occur along a north-south line that parallels the eastern edge of the perching zone, where contaminated groundwater from the Upper Aquifer migrates into the Lower Aquifer. Three of the four wells show increasing trends, while

the fourth well, EW-06, appears stable. The increasing trends in three of the four wells indicate that the Lower Aquifer plumes are not stable.

2.3.2.2.1. The southern portion of the groundwater contamination is centered on hot spot wells, NZ-107 and NZ-84. TCE concentrations have increased from less than 3 µg/L in 2002 to 75 µg/L in NZ-84 and 94 µg/L in NZ-107 in 2015. Nearby, down- and cross-gradient wells show similar trends. See Enclosure 1, Comment 18.

2.3.2.2.2. There are no monitoring wells between the two hot spot wells, NZ-107 and NZ-84, which are over 2,000 feet apart. Therefore, the extent of elevated TCE concentrations is not known in this area and contamination may exist as a single area of contamination as shown in annual reports prior to 2012 rather than two discrete areas as currently interpreted by the Air Force. Also, the apparent decrease in size of the extent of contamination in this area represents a change in how the plume is contoured rather than an decrease in lateral extent of contamination.

2.3.2.2.3. The extent of contamination is not well defined to the north, east, and south of hot spot wells, NZ-107 and NZ-84. For example, there are no appropriately located or screened wells in the southwest, downgradient direction of NZ-84. The Air Force is using the regional monitoring well, RZ-02, to assert that groundwater contamination has not migrated the 3,500 feet distance to RZ-02. However, RZ-02 is screened in a deeper portion of the Upper Aquifer and cannot be considered an appropriate downgradient monitor well since TCE concentrations decline with depth in the Lower Aquifer. The downgradient extent of impacts and the stability of the plume in this area are significant data gaps that should be identified and addressed.

2.3.2.2.4. The Final Tech Memo attributes the increasing TCE concentrations in Lower Aquifer wells, NZ-84, NZ-80, and NZ-107, to the rise in water levels caused by the VVWRA groundwater mound, and does not consider the impacts from the reversal in groundwater flow direction caused by the mound. The Final Tech Memo asserts that the rise in water levels in the Lower Aquifer has intercepted contamination in the vadose zone above the Lower Aquifer (lower vadose zone) in the same way the rise in water levels in the Upper Aquifer intercepted upper vadose zone contamination below the source areas. However, this mechanism appears highly unlikely, since there is no basis to presume, or data to support, the presence of a previously unknown source area in the lower vadose zone.

The assertion that the increasing trends in NZ-84, NZ-80, and NZ-107 are caused by water levels rising into contamination in the lower vadose zone is an unsupported assertion that is contradicted

by the following discussion. Also see Enclosure 1, Comments 18, 24, 27, and 42.

2.3.2.2.4.1. The VVWRA groundwater mound is displacing and diluting contaminated groundwater radially away from the former high concentration wells (e.g., NZ-106) and causing increasing trends in the wells (e.g., NZ-84, NZ-80, and NZ-107) that are currently downgradient of the former high concentrations wells. The effects of the groundwater reversals on concentrations trends in wells is further supported by the abrupt decreasing trends in the former higher concentration wells as the groundwater mound pushes contamination radially away from VVWRA. For example, the groundwater mound has caused NZ-106 to change from a downgradient to upgradient well. This change resulted in an abrupt decrease in TCE concentrations, i.e., from 100 µg/L in 2002 to less than 10 µg/L in 2003 as contamination was pushed away from NZ-106 and toward NZ-84. Similar trends are seen in the monitoring wells in the vicinity of EW-06. The Final Tech Memo's evaluation does not consider the reversal of flow direction or the decreasing trends in these wells.

2.3.2.2.4.2. The Focused FS predicted increasing contaminant concentrations in NZ-84 and NZ-107 based on the change in flow direction and plume migration caused by VVWRA's mound. The Final Tech Memo assumes a new contaminant source in the lower vadose zone as an explanation for the increasing trend, but does not provide any supporting data for the presence of this new source or why the plume will not behave as predicted by the Focused Fs. Therefore, the Focused FS provides the only data-based, regulatory-accepted demonstrations and conclusions regarding the increasing contaminant concentrations in the Lower Aquifer.

2.3.2.2.5. The Final Tech Memo also asserts that VVWRA will stop their discharges in 2017 and that this cessation will result in a "rapid decline" in TCE concentrations in the Lower Aquifer. Firstly, the cessation of VVWRA's discharges is contingent on a number of factors and there is a significant level of uncertainty when the discharge will cease. Secondly, the assertion that TCE concentrations will decline rapidly after discharges cease is unsupported and inconsistent with prior site documents. The Focused FS predicted that after cessation of the VVWRA discharges, groundwater flow would revert to the northeast and contamination would migrate to the Mojave River and the Flood Plain Aquifer. The Final Tech Memo provides no new information that would change the findings of the Focused FS. The Water Board objects to, and rejects, the Final Tech Memo's unfounded assertion and accepts the data-based findings regarding

groundwater movement and plume migration predicted in the Focused FS. See Enclosure 1, Comments 11, 14, 18, 30, 40, and 45.

2.3.2.2.6. The most northern area of groundwater contamination is monitored by a single well, NZ-72. It has been monitored since 1994 and TCE was mainly non-detect until 2013 when there was a sudden increase in concentration. It is not clear if the contamination at NZ-72 is the result of lateral migration of the plume in the Lower Aquifer or downward migration from the Upper Aquifer. The Air Force is working to install additional wells in this area to better delineate the extent of impacts. However, the increasing trends in NZ-72, which is over 3,000 feet from the nearest hot spot, is evidence that groundwater contamination continues to migrate as predicted by the Focused FS model and the plumes are not stable.

Adequate plume delineation in this area is critical to the evaluation of stability and protectiveness because the regional flow in this portion of the site is still toward the Flood Plain Aquifer and the Mojave River. Since the well is just above the bluff of the Mojave River and the Focused FS predicted plume discharges to the drainages in the bluff, the downgradient area of the bluffs should be surveyed for potential contamination in seeps.

2.3.2.3. The Final Tech Memo asserts that the Air Force's current interpretation of the Lower Aquifer contamination as four separate areas reflects plume decay. However, changes in plume configuration over time are also a function of changes in the monitoring network and methods and subjective interpretation used to construct isoconcentration contours (e.g., see Discussion Item 2.3.2.2.2). The impacts of these variables are not considered in the Final Tech Memo. Additionally, determinations regarding the Lower Aquifer plume configuration are subject to a high level of uncertainty because of the deficiencies in the monitoring network and changes in groundwater flow direction. See Discussion Items 2.3.2.1, 2.3.2.2.2, and 2.3.2.2.3. The Water Board has provided comments on the lack of adequate downgradient wells in previous correspondence and recommends the Air Force modify the existing monitoring network in response to the change in plume migration and, propose timely modifications of the monitoring network in the event of future changes in plume migration.

2.3.2.4. Concentrations of PFOS and PFOA in the CG070 plumes are one order of magnitude above the USEPA Health Advisory in the Lower Aquifer. Additional investigation and monitoring is needed to determine the extent of impacts and stability of these highly mobile and recalcitrant contaminants in the Lower Aquifer.

2.3.3. It is not reasonable to expect future plume stability given the following factors.

2.3.3.1. There are significant uncertainties regarding the factors previously described under Discussion Items 2.1, 2.2, and 2.3.1, and 2.3.2, including source control, potential pulse releases, continued plume migration, and the recent results of PFOS and PFOA concentrations above health advisories.

2.3.3.2. There is a high level of uncertainty regarding conditions and factors that could influence plume migration over the long cleanup timeframe.

2.3.3.2.1. See Discussion Item 2.3.2.2.5 regarding changes in discharges from VVWRA.

2.3.3.2.2. Various land use changes could result in ongoing or increased infiltration of water in various locations that could mobilize vadose zone contamination and/or cause changes in the flow regime that could cause additional plume migration. See Discussion Items 2.2.1.2 and 2.4; and Enclosure 1, Comments 40 and 50.

2.3.3.2.3. Episodic infiltration from natural sources, such as the Arroyo and the Mojave River, as well as changes in existing infiltration sources, such as VVWRA, will affect plume migration and cannot be controlled by ICs.

2.3.3.2.4. There appears to be no reliable mechanism to prevent construction of infiltration areas that could influence plume migration in the offsite areas, which are outside of the Air Force's control.

2.3.3.2.5. Increased pumping from existing or new water supply wells could cause further contaminant migration.

2.4. Does the contamination pose a threat to human health or the environment?

The extensive groundwater contamination, its continuing migration, and long cleanup timeframes adversely affect or threaten existing water supplies, representing threats to human health and continuing unacceptable impacts to existing and anticipated future beneficial uses of groundwater, especially domestic water supply.

2.4.1. Anticipated reduction of discharge volumes to the VVWRA's infiltration ponds will result in contaminant migration toward the Mojave River, the Flood Plain Aquifer, and water supply wells, threatening human health and the environment, as has happened previously (see Discussion Item 2.3.2.2.5.) and is predicted to reoccur by the Focused FS. Additionally, because the plume is not stable, the plume continues to threaten the Flood Plain Aquifer, the most productive water supply aquifer for the region, under all potential VVWRA discharge scenarios.

2.4.2. The imposition of ICs for hundreds of years represents an unacceptable long-term loss of a previously reliable water supply. Additionally, ICs will not protect the existing groundwater users, such as VVWRA and the City of Adelanto. Therefore, MNA with the proposed ICs is not protective of human health, especially considering the existing problems with enforcement of ICs

and the very long MNA cleanup timeframe that these ICs will have to be maintained.

2.4.3. The 800 acres areal extent of the combined footprints of Upper Aquifer and Lower Aquifer plumes and the surrounding area, will not be available for critical water management projects, including aquifer storage and recovery (e.g. High Desert Power Plant), and groundwater recharge (e.g., reclaimed water from VVWRA). The continued presence of the plumes and associated ICs will also restrict the construction and use of storm water and flood management projects (e.g., large infiltration basins) in the area. Water management projects are critical to ensure a safe and reliable water supply to the citizens of this desert community in the coming years. The passive remedy of MNA for hundreds of years constrains the ability of the community to adapt to drought conditions and climate change, and places an unfair burden on the citizens of California.

2.4.4. Future need for additional water caused by population growth in this area of limited water resources could increase pumping from existing water supply well wells and well fields. Increased pumping in adjacent areas could cause additional contaminant migration and threaten human health and the environment.

2.4.5. The threats to human health and the environment from PFOA and PFOS in site groundwater have not been evaluated and remain significant uncertainties.

2.5. Can site contaminants be effectively remediated by natural attenuation processes?

The groundwater plumes cannot be effectively remediated solely through MNA, because of the extent of impacts (over 800 acres laterally and 200 feet vertically), the absence of destructive attenuation processes, and the site complexities.

2.5.1. The Focused FS found no evidence of contaminant degradation and concluded that attenuation in groundwater was occurring exclusively from the non-destructive mechanisms of dilution and diffusion. Subsequent to the Focused FS, the Air Force produced the Isotope Study Report (Appendix D of 2012 GAFB Basewide Annual Monitoring and Operations Report) for CG070 that also found little or no indication of the destructive natural attenuation processes of microbial degradation or abiotic degradation. The Final Tech Memo contradicts the Focused FS and the Isotopic Study Report and asserts there is significant mass loss due to destructive (abiotic) processes in groundwater, but provides no site specific supporting evidence for this assertion. Therefore, the Final Tech Memo's assertions are unsubstantiated and the Focused FS and the Isotope Study Report provide the only data-based, regulatory accepted demonstrations and conclusions regarding degradation at Site CG070. Also see Enclosure 1, Comments 46 - 48.

2.5.2. The Focused FS concluded that site data showed no significant attenuation or contaminant loss from volatilization in the lower vadose zone

below the Upper Aquifer and the perching zone. The Final Tech Memo asserts that there is significant TCE loss due to volatilization in that zone, but provides no site specific supporting evidence for this assertion. Therefore, the Final Tech Memo's assertions are unsubstantiated and the Focused FS provides the only data-based, regulatory-accepted demonstrations and conclusions on attenuation and volatilization in this zone. Also see Enclosure 1, Comments 9, 12, 30, 33, 34, and 37.

2.5.3. The Final Tech Memo's support for contaminant degradation is primarily based on its evaluation of concentration trends. However, the Final Tech Memo evaluation of trends and calculation of decay rates include unsupported assumptions, inappropriately applied methodologies, and does not consider factors that control plume migration and affect concentration trends in wells. As discussed under Discussion Item 2.1, the complexities of the site hydrogeology, changing groundwater flow directions, episodic releases of contaminants and infiltration of non-contaminated water, etc., must be taken into account when evaluating concentration trends of site wells. The Final Tech Memo calculates contaminant "decay rates" based on decreasing contaminant concentrations and does not consider these complexities, despite the fact that the regulators have previously informed the Air Force that this method was inappropriate and non-conservative . See Enclosure 1, comments 17, 28, 37, 38, 39, 41 - 44, and 46 - 50.

2.6. Will remedial goals be achieved in a reasonable timeframe?

MNA will not achieve remedial goals in a reasonable time. To date, the Air Force has not submitted an acceptable demonstration that MNA will obtain cleanup goals in a reasonable timeframe for the Lower Aquifer (water supply aquifer) or the Upper Aquifer, which discharges to the Lower Aquifer. The Focused FS's projection of 500 years for cleanup of the Lower Aquifer using MNA is too long to be considered reasonable, especially for a water supply aquifer in an area of limited water resources, and the Final Tech Memo is not a regulatory-acceptable demonstration that MNA will achieve cleanup goals in a reasonable timeframe as previously discussed. Therefore, the Focused FS remains the only regulatory-accepted source of estimates of cleanup timeframes.

The Focused FS predictions of cleanup timeframes were based on complex, calibrated, numeric models that were subjected to sensitivity analysis, and were reviewed and accepted by the Air Force, regulators and an independent consultant. Whereas, the Final Tech Memo's predictions are based on an overly simplistic approach of curve fitting of select data, without consideration of major factors that have controlled these trends, such as changes in groundwater flow directions. Although, the regulators have objected to this approach because it will result in unrealistic low cleanup timeframe predictions and overestimates the protectiveness of MNA, the Air Force has continued with this approach without adequately addressing the regulators' concerns.

Even if the Air Force could adequately support its current assertion that MNA will achieve cleanup goals in 110 years in the Lower Aquifer, the Water Board would not consider this a reasonable timeframe, considering that active treatment is

feasible to reduce the remediation timeframe (see Discussion Item 2.6.5), the future need for the water resource, the threat to existing supply wells and the Mojave River, and the unreliable nature of the ICs over the projected timeframe.

The following are basic technical problems that make the Final Tech Memo's shorter timeframe estimates unacceptable to the Water Board.

2.6.1. The Air Force has not demonstrated a destructive mechanism to support the much shorter cleanup timeframes put forth in the Final Tech Memo. See Discussion Items 2.5.1 and 2.5.2., and Enclosure 1, Comments 28 and 38.

2.6.2. The Final Tech's approach to estimating decay rates is inappropriate and non-conservative as described under Discussion Item 2.5.3.

2.6.3. Based on Water Board comments on the Draft Tech Memo regarding the application of decay rates to wells with stable or increasing trends, the Final Tech Memo applied a different methodology for estimating cleanup timeframes for wells with non-decreasing trends. The new method consists of projecting concentrations in selected wells to downgradient wells, based on the assumption that the water in the selected wells will replace the water in the downgradient well. However, application of this method at CG070 is problematic because of the complexity of contaminant migration and the relatively low density of monitoring wells in many portions of the plumes.

The Water Board cannot accept cleanup timeframes based on this evaluation without a regulatory approved demonstration that the approach is valid for each well it is applied to and that the approach is conservative (i.e., does not underestimate cleanup timeframes). The demonstration should evaluate why the specific wells are not decreasing and include a detailed analysis of each paired well, such as analysis of flow lines over time and chemical signature of the groundwater. See Enclosure 1, Comments 1, 6, 7, 14, 15, 17, 18, 22, 24, 25, 27, 31, 36, 38, 41 – 43, 45, and 46. The Air Force should also provide information on other sites where this method has been applied and discuss the uncertainties associated with this method, e.g. changes in groundwater flow direction caused by cessation of VVWRA discharges.

2.6.4. The Final Tech Memo asserts that the estimates of times to reach cleanup goals in the Focused FS were based on "very conservative assumptions" and were intended only for the purpose of providing a means of comparing the relative performance of the alternatives. The Final Tech Memo concludes that the Focused FS cleanup timeframes were not estimates of actual cleanup times estimates. However, the Focused FS states:

> The time to reach maximum contaminant levels (MCLs) in the Upper and Lower Aquifers, as predicted by the model, is relative between remedial scenarios. **It is likely that all time frames are underestimated** (*emphasis added*) because the model conservatively does not account for back diffusion from fine-grained sediments and because of basic inherent uncertainty in all models.

Additionally, the Focused FS's assumptions and input parameters were carefully considered, calibrated, subjected to sensitivity testing, and were agreed upon by the regulators, the Air Force, and an independent consultant. In contrast, the assumptions and methods of the Final Tech Memo did not incorporate regulatory input and were not subject to an independent review. Therefore, the Focused FS provides the most defensible, regulatory-accepted estimates of cleanup timeframes for CG070.

2.6.5. The Focused FS demonstrated that the relative cleanup timeframe for the Lower Aquifer (water supply aquifer) using pump and treat is five times faster than MNA. The Final Tech Memo contradicts this finding and states that the cleanup time for pump and treat would be the same as MNA, but provides no support for that assertion. The Water Board finds that the cleanup timeframe using pump and treat would result in faster cleanup than MNA as concluded by the Focused FS.

3. Alternatives Evaluation

The Final Tech Memo applies vastly different and non-conservative assumptions, methodologies, and interpretations to the evaluation of MNA than were used in the Focused FS for its evaluation of remedial options and their relative performance. Some of the major differences between the Focused FS and the Final Tech Memo include issues that are critical to the evaluation of MNA, such as natural attenuation processes and contaminant fate and transport, as previously discussed.

Even though the conclusions of the Final Tech Memo are based on very different assumptions and methods than used in the Focused FS, the Final Tech Memo does not reassess other remedial options. Instead the Final Tech Memo asserts that the Focused FS's conclusions regarding the relative performance of the remedial options still applies (even though the Final Tech Memo contradicts the Focused FS conclusions regarding the faster cleanup timeframe for pump and treat, see Discussion Item 2.6.5).

Although the Water Board does not accept the Final Tech Memo's assertions and methods, it is apparent that, if they were also applied to the evaluation of *active* remedial options, the results would probably support different conclusions regarding the various remedies' relative performance than the conclusions of the Focused FS. For example, if, as the Final Tech Memo asserts, natural attenuation will achieve cleanup as soon as 34 years in the Upper Aquifer and the Lower Aquifer contamination is not as widespread as shown in the Focused FS, then focused application of active remediation at specific areas, such as Lower Aquifer hot spots, would be much less costly than estimated in the Focused FS, would result in a shorter cleanup timeframe, and its relative performance could exceed that of MNA.

The Water Board would like to work with the Air Force to update the conceptual site model and refine the evaluations of the Focused FS as appropriate.

However, the Water Board rejects the Air Force's approach to remedial selection, which is based on using a conservative set of assumptions and methodologies in the Focused FS to evaluate and eliminate remedies, using vastly different, non-conservative assumptions and methodologies in the Final Tech to support MNA, and not working collaboratively with the regulators. Not only does this approach undermine the basis for a valid comparison of available remedial options, but it is also inconsistent with remedial evaluation and selection requirements of CERCLA and does not comply with Water Board remedial requirements.

4. Potential Active Remedial Technologies

The Final Tech Memo concludes that anaerobic reductive dechlorination (i.e., biodegradation) is not occurring at CG070. As stated in Enclosure 1, Comment 48, the State agrees there is currently little evidence of biodegradation at CG070, but disagrees with the implied conclusion that biodegradation cannot occur through the use of enhanced reductive dechlorination (ERD) technology, which involves biostimulation of the anaerobic microbes through the injection of an appropriate substrate, (e.g., lactate, edible oils, or commercial available products) into the aquifer.

One of the strongest lines of evidence of reductive dechlorination is the presence of daughter products, particularly, cis-1,2-dichloroethene (cis-DCE). Historically, cis-DCE has been detected at significant levels (approximately 50 µg/L) in the CG070 plumes and in the vicinity of the source area, FT082, where petroleum or other constituents may have stimulated the anaerobic microbes. Significant levels of cis-DCE have also been detected in monitoring wells in the vicinity of the flightline where solvent plumes have mixed with petroleum plumes. The presence of cis-DCE in site groundwater indicates that, if stimulated, in-situ microbes can degrade TCE in groundwater. Although biodegradation can stall at cis-DCE, if the specific microbes (i.e., Dehalococoides) are not naturally present, bioaugmentation (injection of microbial inoculate) can overcome this deficiency. However, bioaugmentation is usually only necessary if biostimulation efforts do not result in complete degradation.

The Focused FS's evaluation of ERD assumed it would take thousands of injection wells to treat the groundwater contamination. However, a more strategic application of ERD in saturated source zones, hot spots, and migration pathways, in conjunction with MNA in the other portions of the plume areas, could be a viable, cost effective remedy that has not been adequately evaluated. Water Board requests that Air Force conduct a pilot test to evaluate the potential application of ERD technology at CG070.

Additionally, the existing GETS could be used to establishing hydraulic control in the event the plume migration threatens the Flood Plain Aquifer and water supply wells. The major problem with the GETS during its operation was the discharge of treated water in areas overlying the plume and adjacent to source areas,

which, not only caused further plume migration, but also mobilized mass from sources. Therefore, different discharge options would have to be developed. Note, VVWRA has indicated it is amenable to receiving and treating TCE-contaminated water from the GETS, although the recent documented presence of PFOA and PFOS may change VVWRA's ability to accept the wastewater.

Conclusions

In conclusion, the Final Tech Memo attempts to address the Water Board's objection to MNA by arguing that MNA will clean up groundwater in a much faster time than the Focused FS's estimates of 200 and 500 years, respectively, for the Upper and Lower Aquifers. The Focused FS and its estimated cleanup timeframes were based on a collaborative effort and regulatory acceptance. Unfortunately, the Final Tech Memo is not the result of such collaboration and many of its assumptions, methodologies, and analyses are poorly supported, unrealistically optimistic (non-conservative), and are inconsistent with the assumptions and methods agreed on for the Focused FS. Additionally, the Tech Memo's simplistic characterization of the site does not provide an appropriate basis for remedial decisions.

The results of multiple, non-conservative assumptions and methodologies, and over simplification of the complex site conditions, are highly unrealistic estimates of cleanup timeframes, and overly optimistic conclusions regarding the protectiveness of MNA. The Water Board cannot accept the Final Tech Memo's conclusions or estimated cleanup timeframes, and absent any adequately supported demonstrations, must rely on the estimated timeframes and conclusions of the Focused FS.

The Air Force's proposal to adopt MNA as the sole remedy at CG070 would consist of continued monitoring of the slow dilution and diffusion of the contamination for hundreds of years, while relying on ICs to protect human health. This passive remedy would result in the following unacceptable consequences:

- Threaten the human health and the area's water supply resources,
- Deny the community access to the water resources for the foreseeable future,
- Constrain the community's ability to implement water management projects and adapt to drought conditions and climate change, and
- Place an unfair burden on the community and the citizens of the State.

Path Forward

The path forward at CG070 must include active remediation to ensure protectiveness and to achieve restoration of groundwater more quickly. The Water Board would like to work collaboratively with the Air Force to build on the Focused FS, refine the conceptual site model, and evaluate active remediation and hydraulic control efforts including, but not limited to ERD.

Primary goals of the remedial system should include prevention of degradation of previously un-impacted groundwater and restoration of the beneficial uses of impacted groundwater in a reasonable timeframe. Achieving these goals may require additional source control measures, hydraulic containment, and active treatment in strategic locations (e.g., hot spots and migration pathways). Because of the continued contaminant migration in the Lower Aquifer and the threat it poses to the Mojave River, its aquifer, and supply wells, it is imperative that, at a minimum, an adequate monitoring network be installed as soon as possible, and hydraulic containment measures be put in place to protect against plume migration toward those receptors.

Thank you for your attention to these important matters. The Water Board looks forward to working with the Air Force to reach resolution of the issues described in this letter. We anticipate a meeting with you and USEPA staff in March or April to discuss active remediation measures. You may contact me at (530) 542-5436 (Lauri.Kemper@waterboards.ca.gov), or Linda Stone, Engineering Geologist, at (530) 542-5471 (Linda.Stone@waterboards.ca.gov), regarding this letter.

LAURI KEMPER, P.E.
ASSISTANT EXECUTIVE OFFICER

Enclosure: Memorandum from Alice Campbell, Department of Toxic Substances Control, GSU, to Linda Stone, Water Board, dated October 7, 2016.

cc with enclosure (via email):

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Tom Thornton, City of Adelanto, Operations
Valerie Wiegenstein, Mojave Water Agency

LSt./ma/T: GAFB WB comments Final OU1 MNA TM
File Under: GeoTracker

Department of Toxic Substances Control

Matthew Rodriquez
Secretary for
Environmental Protection

Barbara Lee
Director
9211 Oakdale Avenue
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MEMORANDUM

TO: Ms Linda Stone, PG, CHg
Engineering Geologist
Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd
South Lake Tahoe, CA 96150

FROM: Alice Campbell, PG, CEG, CHg
Senior Engineering Geologist
Chatsworth Geological Services Unit

CONCUR: Craig Christmann, P.G.
Senior Engineering Geologist
Chatsworth Geological Services Unit

DATE: October 7, 2016

SUBJECT: Technical Memorandum, Evidence for Natural Attenuation, Site CG070, OU1, dated May 2016, by CB&I Federal Services LLC, for Former George Air Force Base, Victorville, California.

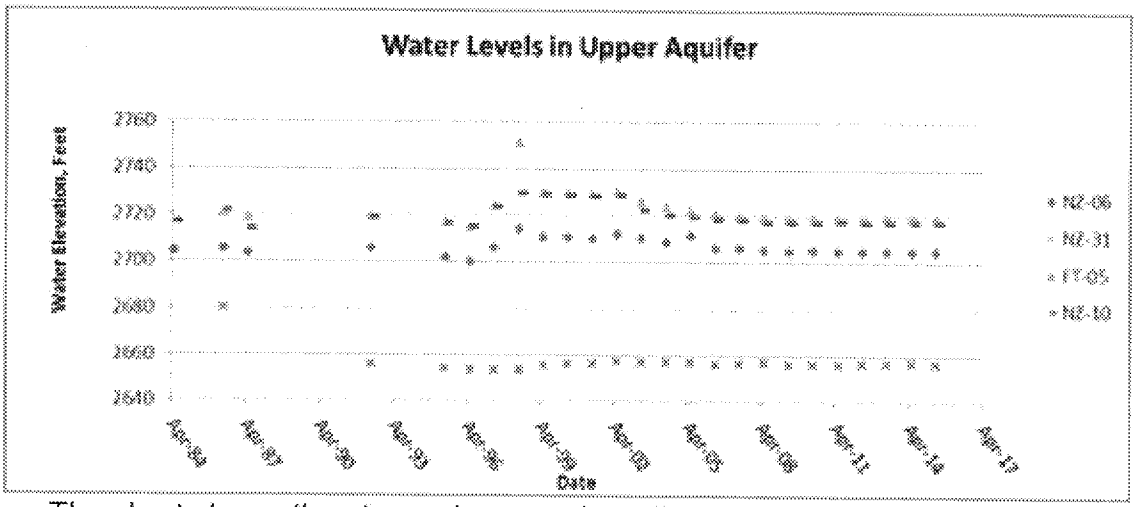
PCA: 14718 Site Code: 400071-47 Work Request No.20025728

Introduction:

At your request, Chatsworth Geological Services Unit (GSU) staff has reviewed the Tech Memo OU1 described above and dated May 2016. The report summarizes CSMs, data and calculations for rates of natural attenuation of contaminants at the former AFB. Site CG070 is the main VOC plume on the north half of the base. This review focuses on the mathematical modeling used to calculate attenuation rates, and recharge to groundwater from rain or applied water, and evaluate the calculations for cleanup goals.

Comments.

1. Section 3.1 Hydrogeology. Upper Aquifer. The groundwater flow section is oversimplified. Groundwater flow directions have changed between 1995 and the present both from drought, recharge, and pumping. In 1995, groundwater flowed north in the fire training source areas, and east near the end of the runway. By 1998, groundwater was mainly flowing north-northeast. There are strong downward gradients in Upper Aquifer because its base, the Middle Lacustrine Unit (MLU) is leaky.



The chart shows the strong downward gradients in the Upper Aquifer east of FT-083. The subdued response at NZ-31 shows that the MLU has low conductivity and only responds slowly to changes in water levels.

2. Hydrogeologic Setting, Cross Sections and Block diagrams. The cross-sections are simplified from the boring logs, but several important features of the upper and lower zone are missing. Both the Upper and Lower Aquifers have different depositional directions, and none of the sections show their slope. The Lower Aquifer slopes down to the west, and the upper zone slopes down to the northeast, as described in the 2005 Hydrogeologic Conceptual Site Model(HSM). These are important features for understanding groundwater flow, and the sections should be revised.

3. The MLU/PLZ fine-grained units should extend beneath parts of the Upper Aquifer that is saturated. Figure 3-17 shows saturation in the Upper Aquifer but has no fine-grained units to explain what it is perching on. Many of the boring logs were only described at ten-foot intervals, so they cannot be relied on entirely for lithologic data. If there is sufficient permeability contrast to perch water, there is sufficient fine-grained material to show on a section. Several

Upper Aquifer wells (using the definition that the bottom of the screen is above the calculated plane of the top of the MLU) are found near the northern VVWRA ponds, including NZ-99, indicating the perching layer is present. Because the sections were used for the block model, missing layers need to be added to the block model also.

4. The block diagrams and sections would be improved if they used pattern for lithology, and color for contamination. Using yellow and red for both concentration and lithology places an undue decoding burden on the reader.

5. There is practically no soil mechanical analysis data collected to confirm the lithology and support mathematical modeling. As mentioned above, borings were often logged on 5 and 10-foot intervals, and where piezocone data exists, logs show the materials have much thinner beds and more heterogeneity. The report should have some uncertainty analysis that discusses the effect of estimation of soil properties on velocity calculations and calculations of the mass of contamination.

6. CSM. 3.1 Flow directions. The first paragraph should state that post-GETS flow in the Lower Aquifer is radially away from the VVWRA, so it is towards the south, west, or north, depending on location. In the FPA, VVWRA operations and ponds also alter local flow directions. Flow in the Lower Aquifer has changed from eastward to westward and northward after the extraction wells shut down and the VVWRA ponds began operation in 2001. MWH noted this change in direction in the FFS (2012).

7. 3.1.3 and CSM Figure 2-4: Despite statements that the CSM has been evolving, Figure 2-4 has not been updated to show new information. Flow in the Lower Aquifer switched direction around 2002, so flow arrows should point west at VVWRA ponds. There is no Shay Road fault. The Arroyo that drains the runways should be shown as a local recharge area. The Lower Aquifer itself was deposited on a surface sloping to the west, and should not be shown as horizontal.

8. 3.1 Both the Upper Aquifer and the MLU act as leaky aquifers, with both horizontal and vertical flow components. The Upper Aquifer has horizontal flow and strong vertical gradients because of leakage from the base of the MLU. The MLU has both horizontal and vertical gradients (with horizontal about ten times vertical)), but the rate of flow in each direction is lower because it has lower overall hydraulic conductivity. Therefore, VOCs drain both **over the edge** of the MLU (forming mounds on the Lower Aquifer), and leak slowly **through** the MLU into the Lower Aquifer (forming broader but lower mounds). MWH calculated a ratio of radial to vertical conductivity of about 0.001 for the

Upper Aquifer. However, the hydraulic gradient in the upper zone is about 0.001 ft/ft, while the head on the MLU is about ten feet/ft. So the ratio of **flow** horizontally to vertically is about 0.01, or about one percent. This calculation shows that most of the contamination tends to reach the Lower Aquifer by draining over the edge of the Upper Aquifer.

9. Beneath the MLU is another unit, the lower vadose zone, which is about 50 feet thick. It is composed of layered alluvial sands and silt resembling the Lower Aquifer. The lower vadose zone has just one geotechnical sample for the entire base and is thus poorly characterized. Leakage from the base of the MLU must traverse this zone to reach the Lower Aquifer. The lower vadose zone is exposed in the bluffs along the River. Weathering and burial would be expected to increase bulk density and decrease effective porosity and hydraulic conductivity. Low air exchange and high moisture would be expected in this zone. The MWH CSM(2005) and the Supplemental Study in the FFS(2012) said that the lower vadose zone was practically saturated and would not support extensive volatilization of VOCs. No soil gas data has been obtained for this unit. The document should include a description of this unit, particularly because of claims of extensive volatilization in this zone.

10. 3.1 The 2005 HSM discussed refinements to the definition of the MLU, but its definition does not always produce a contourable groundwater surface. After finding that the HSM's MLU definition did not produce reasonable groundwater contours, and that weeding contours by hand was time-consuming and prone to bias, GSU calculated a simple top surface plane of the MLU using elevation 3730 at the north end of the base and elevation 2660 at the south end of the base.(This definition is consistent with the 2005 description of the MLU as time-transgressive from north to south.) GSU then divided the MLU into three layers about ten feet thick each (M1, M2, and M3), and sorted the wells by which layer the *lower* end of their screens fell into. M1 is defined as extending from 6.6 feet above the plane to 12 feet below the plane (about 19 feet thick). M2 extends from 12 feet below the plane to about 22 feet below the plane. M3 extends from 22 feet below the plane to 44 feet below the plane. Below the M3 layer, all wells contour with the Lower Aquifer or FPA. Extraction wells with long screens that crossed MLU zone boundaries were excluded from contouring. Wells with the base of the screen more than 6 feet above the plane of the MLU were called Upper Aquifer wells. These subzones, when contoured, produce contour maps that do not require picking and choosing wells to produce smooth surfaces. The lower layers also have smoothly contourable surfaces with parallel but successively lower elevations. The Upper Aquifer and M1 zones are similar to the west, and increasingly different to the east. The deeper two levels of the MLU are geographically constrained, suggesting the Pliocene lake

that formed these deposits started small and migrated westward and southward from near the River early in its history. Contamination 'stair-steps' down the MLU as it travels to the north and east from sources in the south and west of OU1. The division of the MLU into sub-zones improves the accuracy of calculation of remaining contaminant mass, and clarifies many details of flow between the Upper and Lower aquifers.

The following tables show the layer assigned to each well based on the difference between the well's calculated MLU top elevation, and the elevation of the bottom of its screen.

Wells Assigned to M1

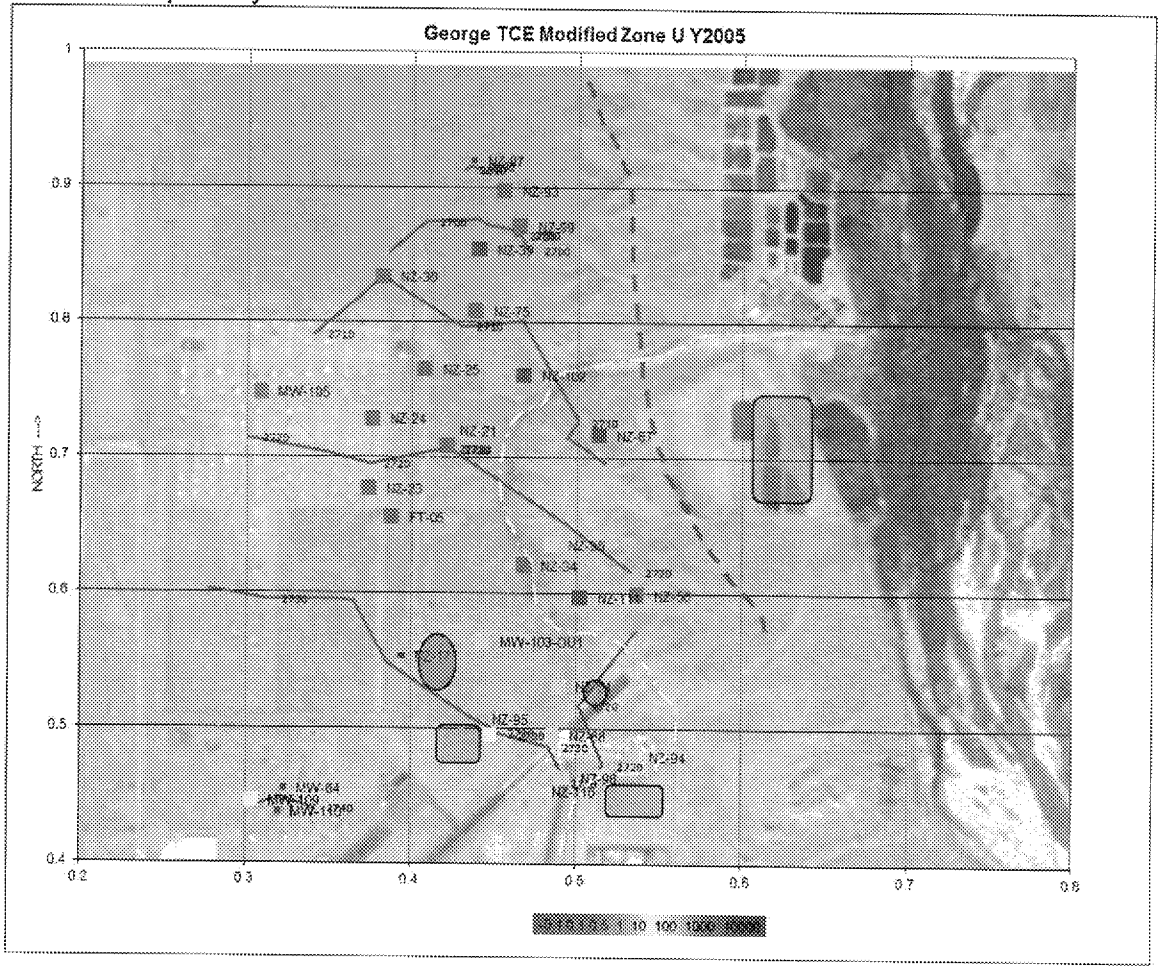
Name	MLU-Screen Bottom, ft.	Name	MLU-Screen Bottom, ft.	Name	MLU-Screen Bottom, ft.
CZ-02	-10.23	MW-28	0.56	NZ-11	-7.79
EW-03	1.6	MW-29	2.75	NZ-12	-6.13
EW-10	-7.58	MW-30	4.04	NZ-122	2.71
EW-11	5.89	MW-31	1.77	NZ-125	5.29
EW-13	5.3	MW-32	2.27	NZ-126	5.59
EX-01	2.52	MW-33	0.35	NZ-16	-9.45
EX-02	4.55	MW-34	3.15	NZ-27	-0.26
EX-03	3.23	MW-35	4.85	NZ-28A	5.26
EX-04	2.75	MW-36	1.63	NZ-33	-9.25
MW-120	0.58	MW-40	4.63	NZ-42	-11.22
MW-137	-3.12	MW-45	1.08	NZ-43	-7.54
MW-153	5.71	MW-46	4.7	NZ-49	6.59
MW-154	2.93	MW-47	4.82	NZ-51	1.54
MW-155	-7.52	MW-53	-6.68	NZ-52	-4.69
MW-158	2.87	MW-53_Redrill	-6.68	NZ-81	0.06
MW-17	5.16	MW-56	5.96	NZ-91	3.31
MW-18	6.39	MW-57	5.9	RZ-01	-11.82
MW-20	1.08	MW-58	4.46	SMW-01	6.22
MW-21	4.04	MW-62	2.81	SMW-03	5.85
MW-23	5.47	MW-63	5.12	SZ-04	3.4
MW-24	4.27	MW-85	0.65	SZ-06	6.39
MW-25	5.54	NZ-01	0.45	SZ-08	-10.5
MW-26	1.98	NZ-07	-11.04	SZ-10	-11.82
MW-27	3.63	NZ-103	3.7		

Wells Assigned to M2			
Name	MLU-Screen Bottom, ft.	Name	MLU-Screen Bottom, ft.
EW-04	-14.49	NZ-10	-17.09
EW-09	-23.4	NZ-121	-16.37
FT-01	-14.5	NZ-123	-37.4
FT-02	-28.54	NZ-14	-15.46
FT-03	-17.49	NZ-15	-14.66
FT-04	-16.9	NZ-22	-14.7
MW-104-OU1	-17.83	NZ-38	0.42
MW-106	-34.9	NZ-40	-22.57
MW-157	-12.16	NZ-46	-12.75
MW-52	-29.53	NZ-47	-44.28
MW-54	-34.15	NZ-66	-26.25
MW-55	-14.03	SW-01A	-14.51
MW-65	-13.15	SW-01B	-14.03
MW-86	-29.53	SZ-09	-17.81
MW-87	-22.05	SZ-15	-22.82
MW-88	-22.49	SZ-03	-14.5
NZ-08	-34.14	SZ-11	-14.39
NZ-09	-39.24		

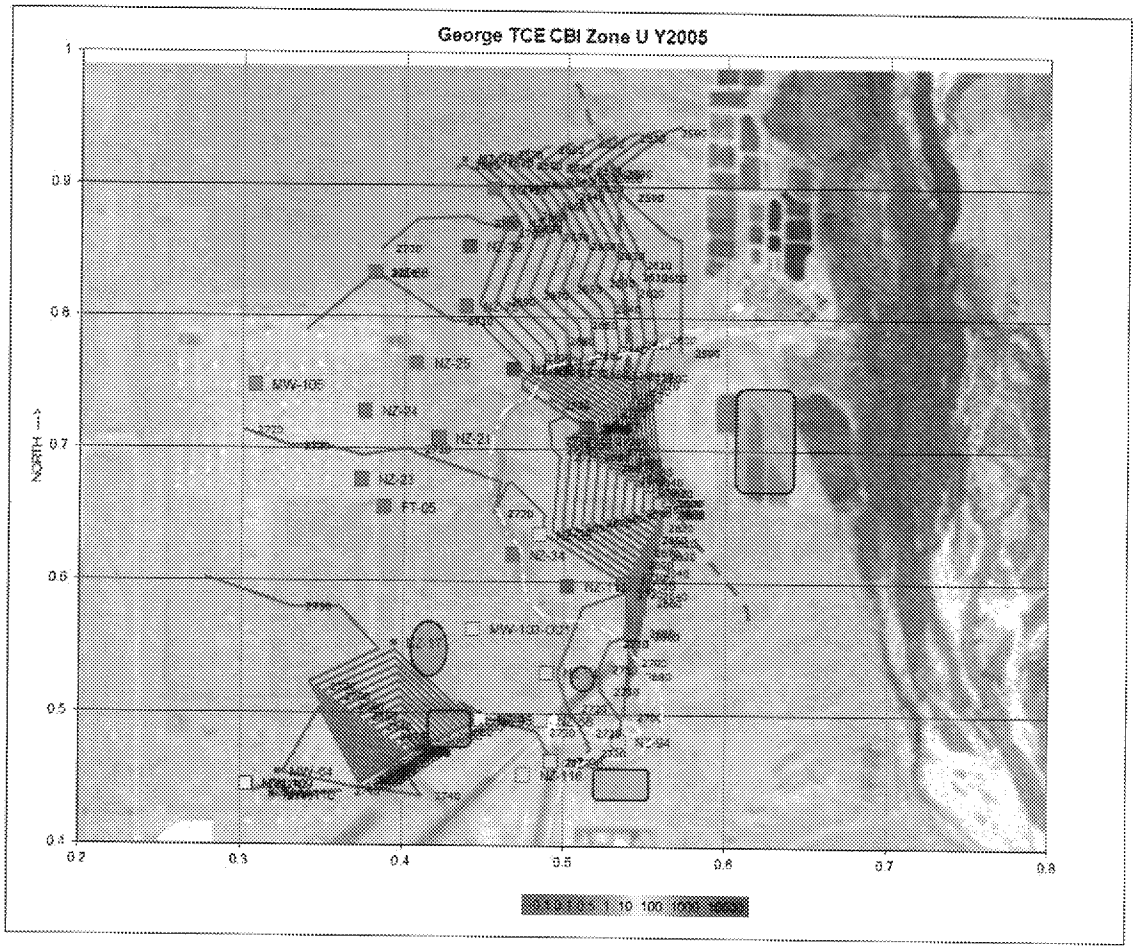
Wells Assigned to M3	
Name	MLU-Screen Bottom, ft.
MW-102-OU1	-25.57
NZ-06	-23.82
NZ-20	-17.44
NZ-30	-22.97
NZ-31	-27.13
NZ-32	-34.29
NZ-37	-105.19

The Upper Aquifer has always been problematic to contour when MLU wells are included. Upper Aquifer (including MLU) wells have been screened anywhere between 50 feet above to 50 feet below the calculated top of the MLU. Because of the differing placements of screens, Upper Aquifer contours are often

unsatisfactory, and historically, water levels that don't fit have been removed by hand, one by one, until a satisfactory map results. This can introduce unconscious bias and different people will produce different maps, regardless of what method is used to contour. As described above, GSU simplified MWH's MLU definition (as described in Appendix B of the FFS) to separate wells and produce contourable surfaces. The upper surface of the MLU was defined from north to south, and its elevation was interpolated at the location of every well at George. Then the bottom of the screen was compared with the top of the MLU. Interestingly, the MLU surface did not need to be adjusted near the VVWRA ponds, suggesting that the latest MWH MLU map did not identify the topmost MLU surface. The CSM should be revised to better reflect our current knowledge of this complex system.



Upper Aquifer contours using screens ending 6.6 feet or more above plane of MLU surface.



Upper Aquifer contours using CBI's current definition of Upper Aquifer wells. Many wells need to be removed by hand to make a contourable surface.

The contours show why horizontal flow is better contoured with a set of wells perforated in the same horizontal interval to remove artifacts caused by downward gradients.

11. Section 3.3 The last paragraph states that "undisturbed" Lower Aquifer migration pathways are to the northwest. This statement vastly oversimplifies how groundwater flows in the Lower Aquifer. Before the VVWRA ponds were used, groundwater appears to have flowed eastward from the Lower Aquifer into the River. This is based on the chloride concentrations at NZ-03 measured

in 1986-1987 groundwater analyses being slightly higher than in wells in the floodplain aquifer (FPA), which suggests that in 1987, the Lower Aquifer drained eastward to the River. A possible exception is near the northern VVWRA ponds, where the groundwater mound caused a northward detour of water flowing beneath the Arroyo. The southern VVWRA ponds began operation in 2002, diverting nearly all flow in the Lower Aquifer to the north, west and south away from the ponds. If the southern ponds stop operating, Lower Aquifer flow south of the bend in the Arroyo will flow east to the Mojave River. The concept of 'undisturbed' flow in the Lower Aquifer depends on how the word 'disturbed' is defined. The Lower Aquifer has been disturbed in the past by recharge mounds along the River, and may be disturbed in the future by flooding and by changes in discharge rates to the VVWRA ponds. The text should be revised to explain how the Lower Aquifer has responded to artificial disturbance over time.

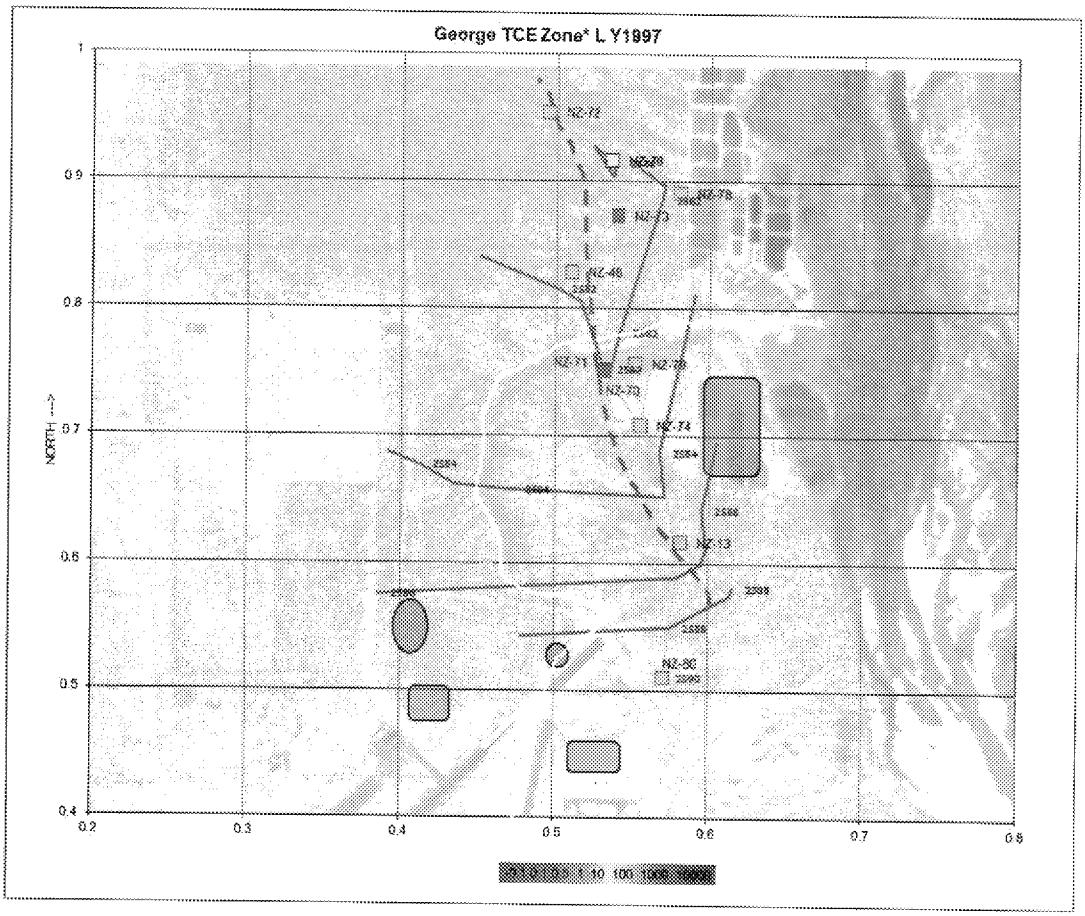
12. 3.4.2 As described above (comment 9), the Upper Aquifer and the MLU behave differently and are better considered as separate aquifers. They act both as leaky aquifers with downward flow and perching layers with horizontal flow (shown by TCE flowing both down and horizontally in both the Upper Aquifer and the MLU). GSU disagrees that there is very much sorptive capacity left in the MLU, because the 1986 pulse would have already contaminated the MLU. High saturation below the MLU prevents very much volatilization in the lower unsaturated zone. Without hard data on VOC concentrations, effective porosity and moisture content, any attempt to calculate VOC concentrations in the lower vadose zone is speculative at best. The text should be revised to remove speculative comments on sorptive capacity of the MLU and volatilization in the lower vadose zone.

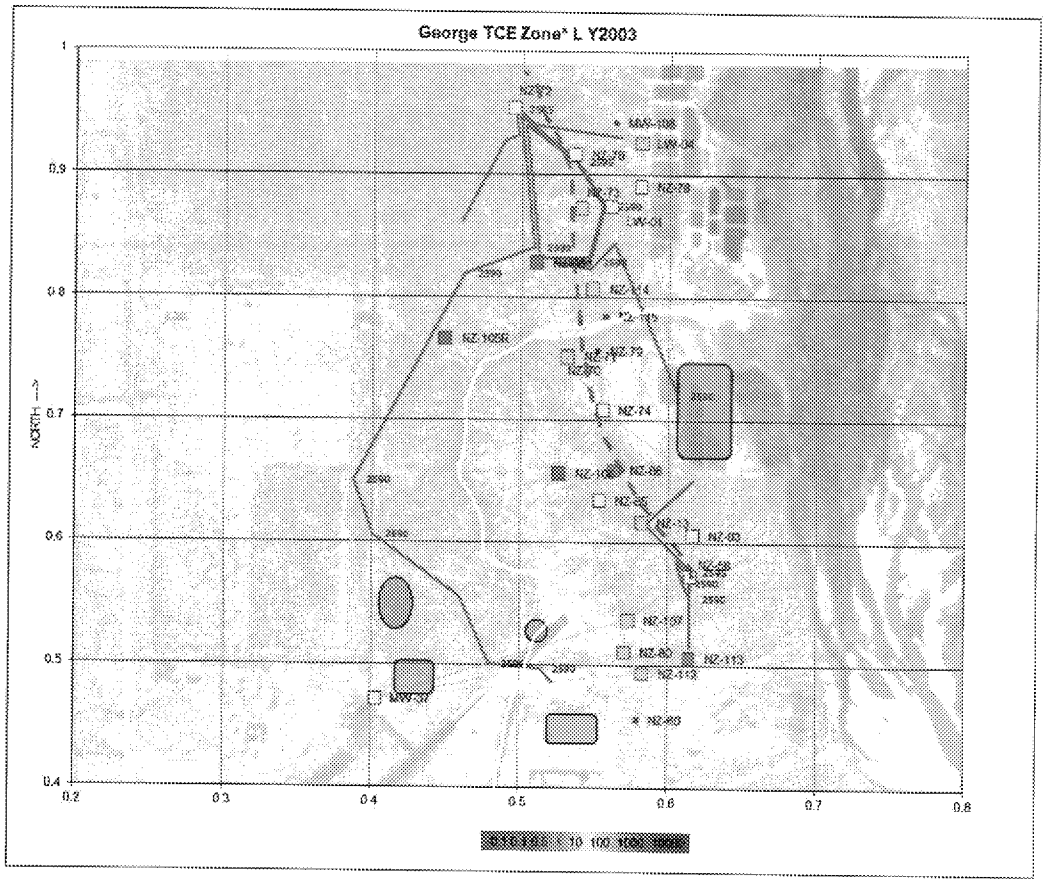
13. Upper Aquifer: In 2013, wells near the Arroyo, including NZ-111, NZ-56, NZ-35 and NZ-82 surrounded a small groundwater mound with radial flow. This mound may be a recharge mound in the Arroyo from rainwater from the runway drainage system into the Arroyo, or recharge in the old sewage treatment plant percolation (STP) ponds, which have never been graded to drain to the Arroyo, and pond water during rainfall events. PCE was detected in 2013 at NZ-56 and NZ-35. PCE detections can be seen stairstepping down through the MLU and into the Lower Aquifer in the area east of the end of the runway. Earlier releases that included PCE have been detected at NZ-32, showing that groundwater that flows eastward from the area of the STP ponds flows around the end of the VVWRA groundwater mound to the River.

14. Lower Aquifer Changes in the Lower Aquifer's flow direction have been caused by both recharge from the Upper Aquifer and discharge to the VVWRA ponds,

and altered the flow direction of the TCE plumes. Cessation of discharge in the VVWRA ponds may allow the plumes to migrate back to the river. These changes were discussed in the FFS and need to be discussed in this document along with their impact on plume migration.

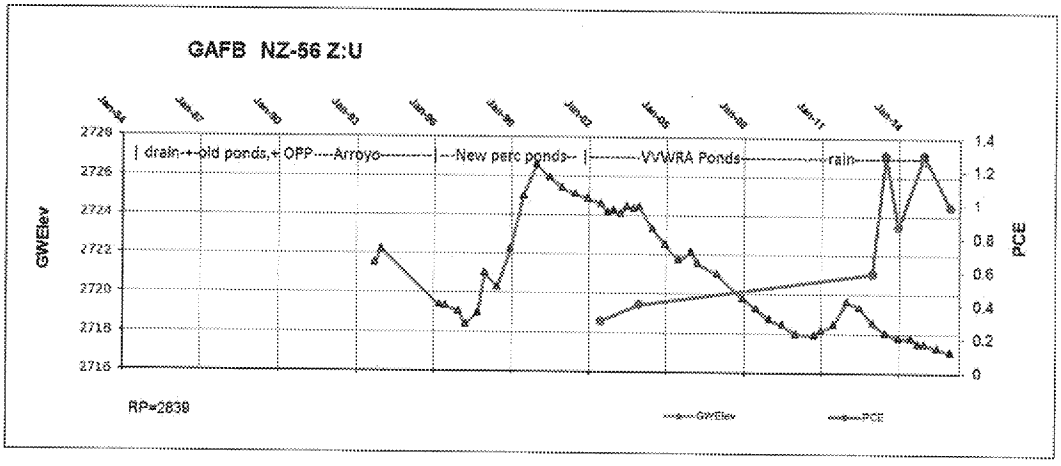
15. Lower Aquifer Geology: Contours of the Lower Aquifer in both 2003 and 2005 show closed oval contours, suggesting strongly anisotropic flow conditions.NZ-86 encountered 10 feet of gravel at 159-169 ft bgs; NZ-72 has 25% gravel at 165 ft bgs; and NZ-71 has gravel at 165'. Lower Aquifer contours for 1995, 1997, 1999, 2001, 2005, 2014 also have a pronounced vee along a line that coincides with the coarse gravels, with high TCE concentrations generally along the vee of the channel. This suggests the Lower Aquifer has stratigraphic trapping of contaminants in a coarse channel deposit, which trends about 15 degrees west of north. This feature was not identified in the FFS or the current document. The apparent channel appears to control overall Lower Aquifer contaminant distribution, and may be a useful target for remediation because it is a natural conduit for contamination. The channel and its impact on contaminant migration should be included in the CSM and considered in the Tech Memo.


George TCE Zone* L Y1997
NORTH --->
1
0.9
0.8
0.7
0.6
0.5
0.4
0.2
0.3
0.4
0.5
0.6
0.7
0.8
MZ-72
MZ-73
MZ-45
MZ-71
MZ-74
MZ-13
MZ-50



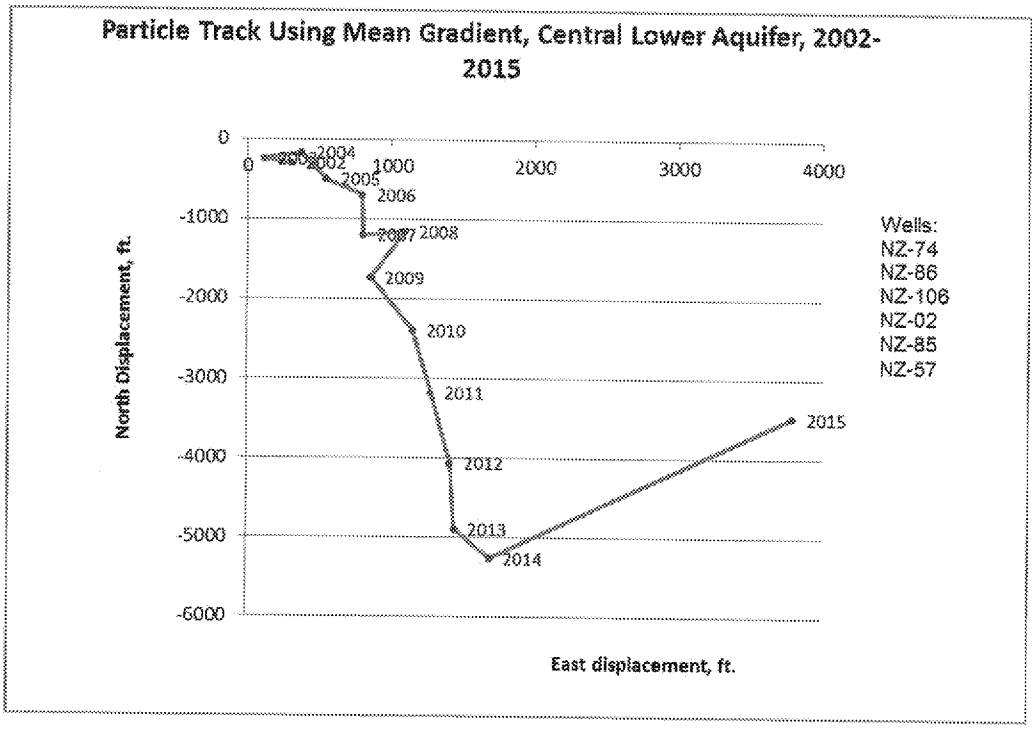
The above two figures show the effect (orange dashed line)of a suspected buried channel in the Lower Aquifer that appears to have some control on groundwater flow direction. The FPA wells are not included. The 1987 contours predate the VVWRA southern ponds, (green rectangle) so the mound along the river is likely from river recharge. The lower figure shows westward flow caused by a groundwater mound beneath the VVWRA ponds.(the orange shapes are VOC source areas, the green shapes are recharge areas).

16. Groundwater Recharge. The STP ponds may be a continuing source of groundwater recharge in wet years. Last year's perfluorinated compound study detected a plume of PFCs downgradient of the STP ponds. The 2005 HSM shows the STP ponds as possible source areas, along with the industrial and storm drain system. The STPs are a known source of nitrate and a suspected source of PCE, and these two compounds are good indicators of the extent of the contamination originating beneath the STP ponds and the southern part of the flight line, both in the Upper Aquifer and in the Lower Aquifer.



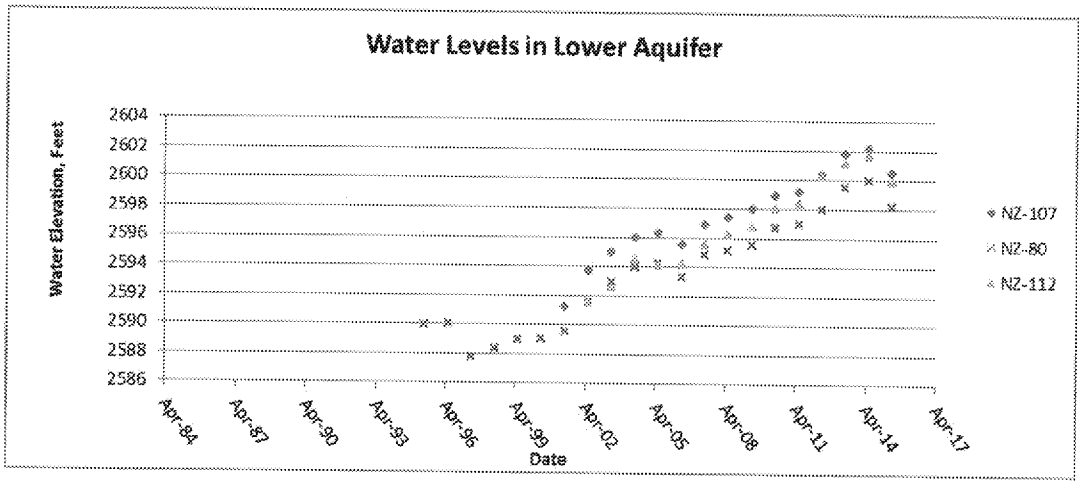
This figure shows a pulse of PCE a year after a rainfall event that caused a water level rise of over 2 feet near the well. This chart shows that preventing infiltration in the STP ponds and fire training areas will prevent remobilization of residual VOCs and nitrate in the Upper Aquifer. The Tech Memo should be revised to discuss this potential source and recommend actions to mitigate it.

17. Section 3.4.6. The time series plots are unreliable as indicators of decay rates. They only show decay if the plume direction never changes, and the well is always in the plume. This is clearly not the case, because there have been many changes in flow direction over the past 40 years, and because every recharge mound or extraction well changed the location and direction of plumes, along with Arroyo recharge during wet winters. The rapid increases and decreases in TCE concentrations shown on time series plots are better explained as changes in plume direction, particularly if they occur with rapid changes in water levels. The attenuation analysis needs to be done in a way that isolates periods when the flow direction can be shown to have been constant. The following figure shows the change in mean flow direction for the central part of the Lower Aquifer near the VVWRA ponds. Groundwater flow reversed from west to east in 2003, then headed southwest until 2006. In 2007, flow directions were due south, then turned east in 2008. In 2009, flow headed southwest, then turned to southeast in 2009. Flow gradually shifted to due south in 2013, then to the southwest in 2014, and northeast in 2015.



The chart shows reversal and turns in groundwater gradient since 2003. This figure shows why the TCE time series need to be compared with local gradients to find out whether the plume has drifted away from the well.

18. Section 3.4.6 Last bullet. The increase in nitrate at NZ-80 pairs with rapid decreases in TCE, coincident with the rise in water levels. Nitrate increased when the plume direction changed to southeast when the southern VVWRA ponds began operating. The two separate pulses in nitrate coincide with changes in the rate of spreading, showing that even the nitrate plume shifted when the amount and location of spreading changed. Note that TCE has been detected at floodplain well NZ-132c, showing that there is a eastward flowpath south of the VVWRA ponds for groundwater that reaches the Lower Aquifer at the east end of the runway. Groundwater at NZ-107 originated near the STP ponds, initially moved north, then was pushed southwest by the VVWRA southern mound, showing that under current conditions, Upper Aquifer water east of the STP ponds flows east and down to the Lower Aquifer, not north. The nitrate did not originate at the VVWRA ponds, because the TCE and PCE show that it came from the nearby STP ponds. There is nothing to stop groundwater at NZ-80 from reaching the River near NZ-132. These changes in groundwater flow directions and contaminant migration should be discussed and considered in the Tech Memo.

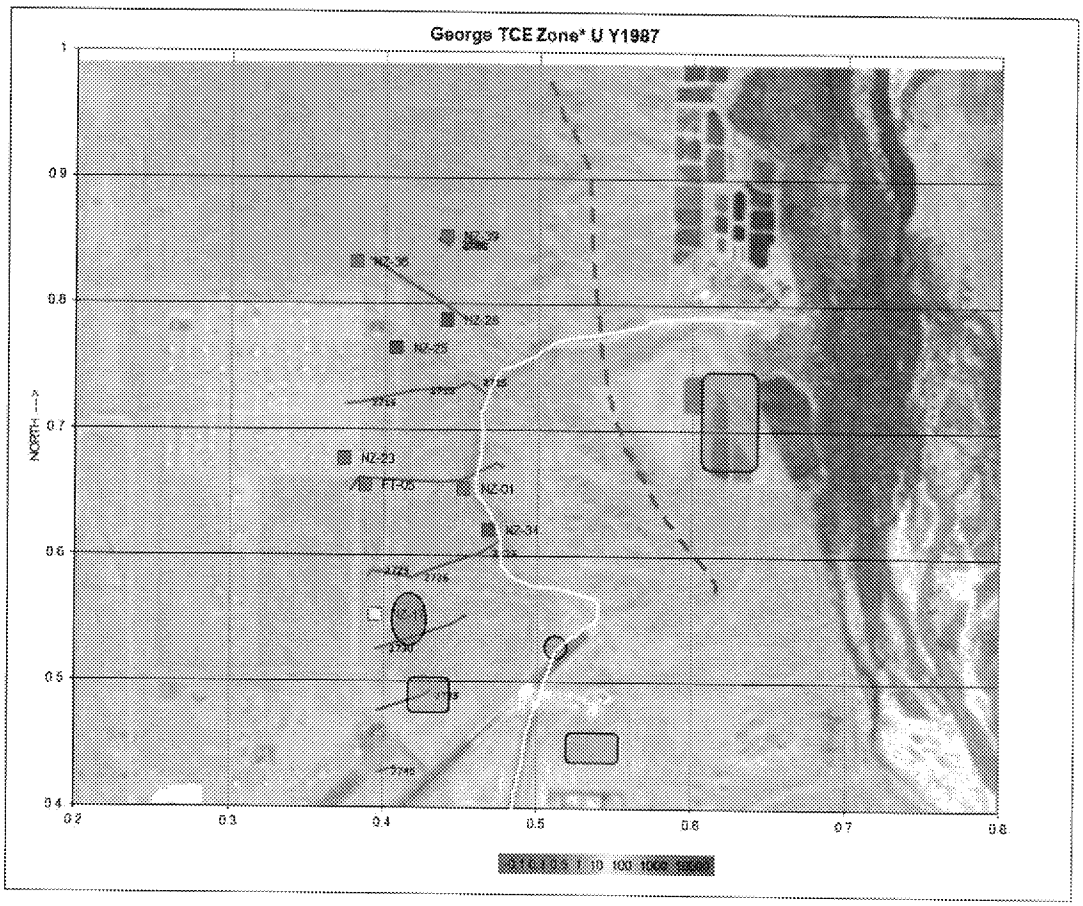


This figure shows how groundwater gradients have changed with time east of the STP ponds. If groundwater flow direction had not changed, the lines would be parallel. Instead, NZ-112 starts out at the same elevation as NZ-80, but gradually increases to the same elevation as NZ-107. The collapsing Upper Aquifer mounds and the growing VVWRA mound have gradually shifted NZ-80's flow direction.

Section 3.8. Comments

19. There have been at least two major VOC release episodes at the Base: one that was in progress in 1983, and one in the late 1990s, which can be split further into two segments by differences in the location of spreading. Both releases occurred when groundwater levels in the Upper Aquifer were low, and infiltration increased by discharges into the Arroyo, or from discharge into the STP and NP ponds. The increased percolation rates caused groundwater to rise into contaminated layers in the deep vadose zone. The timing of contamination at wells varied with the distance and direction to the contaminant source and the nearest groundwater mound. Unlike the 1997 release, which was observed in many wells, very few wells observed the early 1980s release, and in many cases, high TCE levels were only observed in the initial sample from the well. Some discussion of the earlier pulse is important because it shows that the 1997 event was not a one-time event. The origin of the first release can be deduced from the earliest OU1 data. Although the first plume was in the same general area as the second release, there are some differences due to changes in the specific locations where water was being discharged to the surface. The early 1980s release happened after the very wet winter of 1982-83, which produced 16 inches of rain over a 5-month period. At this time, the STP ponds were in operation, and the runway drainage system

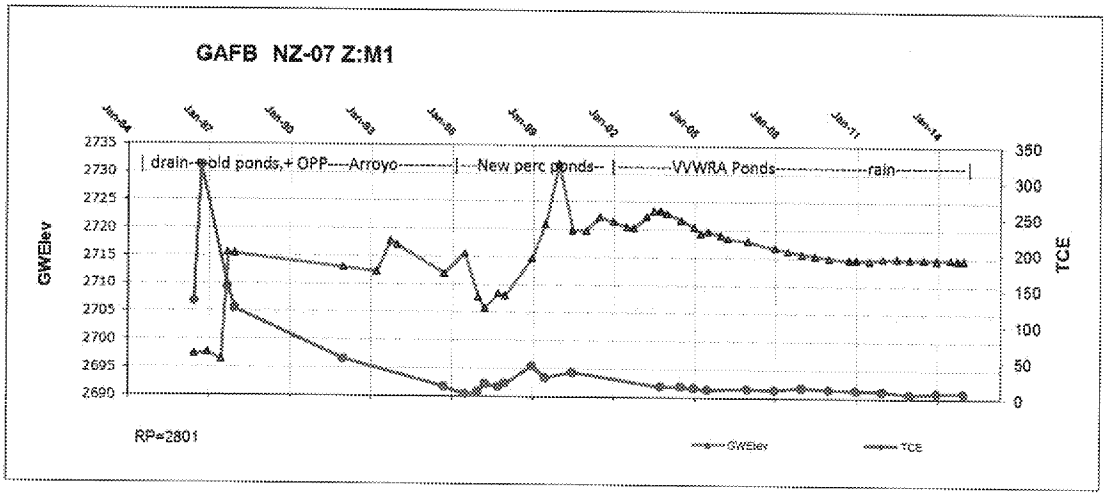
including the industrial storm drain was operating. Groundwater contours for 1983 and 1987 show that groundwater originates south of the fire training areas. The limited datasets suggests that water infiltrating from the old Industrial Storm Drain (ISD) system and the STP ponds created a mound in the Upper Aquifer that moved north past the fire training areas, and picked up solvents beneath the fire pits. The ISDs were built using gravel bedding and perforated CMP in some places, and TCE was found in the sludge in the storm drain pipes in the RI studies (the East SD was removed in 1989). The current storm drain system is still, however, a persistent source of recharge to the Upper Aquifer in wet years, as shown by abrupt rises in water levels during 2010-11 in nearly all shallow wells near the flightline. This was also a wet winter (10 inches in two months). The following contour map of the Upper Aquifer for 1987 shows groundwater flow to the north from the flightline area towards the FT-019 area. There are no other obvious sources of the required amount of infliltrating water, in the correct position, to drive the 1983 pulse.



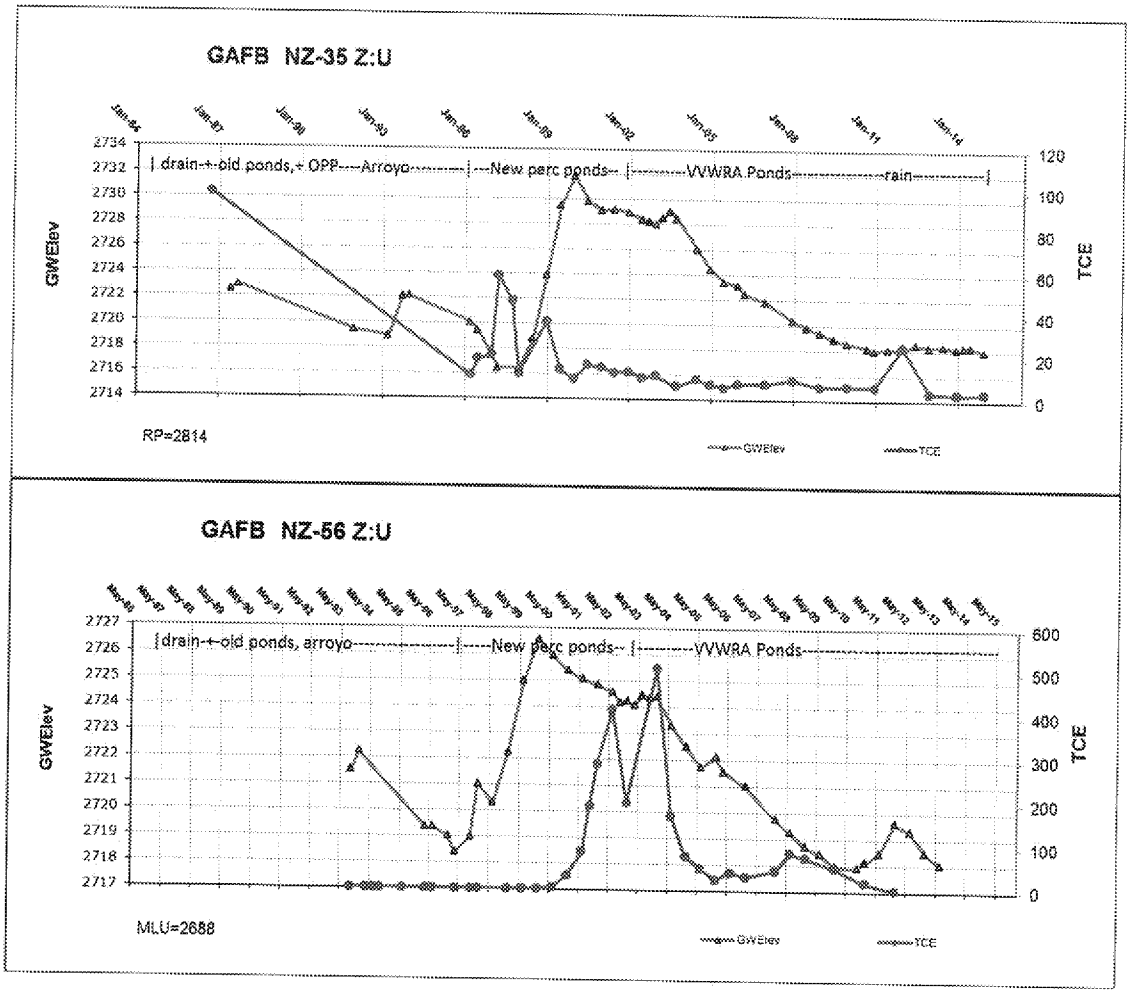
The 1987 groundwater elevation contours for the Upper Aquifer show the northward groundwater flow from the flightline area, and tipping north of the east

ends of contours suggesting a mound under the STP ponds. Water levels beneath FT019 were at about elevation 2730, about five feet higher than currently. Section 3.8 item 1 states that infiltration below the STP does not affect water levels, but this and other data shows that there are increases in water levels in shallow wells near the STP in wet years. The Tech Memo and the CSM should be revised to reflect the complex history of releases as pulses for various source areas.

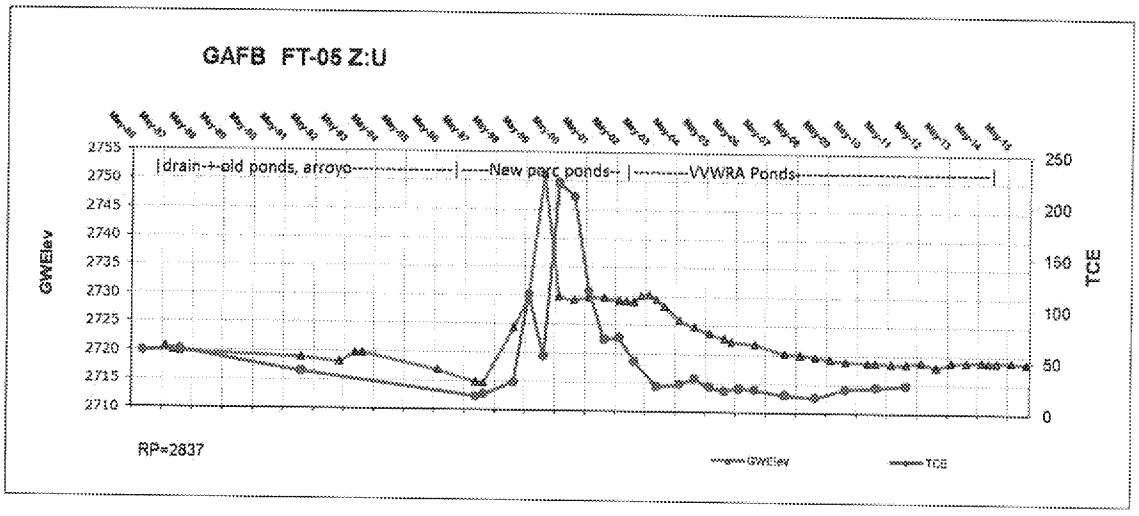
20. The following time series illustrate the different pulses:



This is the first pulse in the 1980s. NZ-07 is west of the Arroyo and north of FT082. It did not react to the infiltration at STP and NP ponds from 1990 to 2003, so the contamination did not come from either the STP pond area or the fire training areas. The peak is sharp, so the well is near the source. Water levels rise after the peak, suggesting more flow into the Arroyo in 1987. The well has high nitrate and PCE detections, so some water originated as industrial wastewater and percolation from the STP ponds. Water containing TCE may have been discharged down the arroyo, possibly in a high rainfall event such as occurred in the very wet winter of 1982-1983.



NZ-35 is near the Arroyo. This well shows the 1980s TCE pulse (first pulse), then a second TCE pulse in 1997, following spreading in the STP and Arroyo, then a second TCE pulse in 1999, followed by a second, much higher water level rise in 2000. The first TCE pulse at this location appears to have come from Arroyo discharge, the second from spreading in the STP, and the third pulse is from the new percolation ponds (NP ponds). This well has PCE and nitrate, so the water mainly originated from the area of the STP ponds. Note the 'M' shape of the 1995-1999 pulses, this double peak is distinctive and is found in several wells downgradient of the STP ponds such as NZ-56.



FT-05 shows the typical signature of the third TCE pulse in 1999.

Concentrations did not rise in this well until the NP ponds were put in operation. The wells north of the fire training areas have this single peak, and no nitrate or PCE, or very little PCE. The irregularity in the rising limb seems to be related to dilution by freshwater, after which spreading rates were reduced. However, no other well shows such a high water level on the date this peak was measured, and the measurement could be in error. The Tech Memo and the CSM should be revised to reflect the complex history of releases as pulses for various source areas.

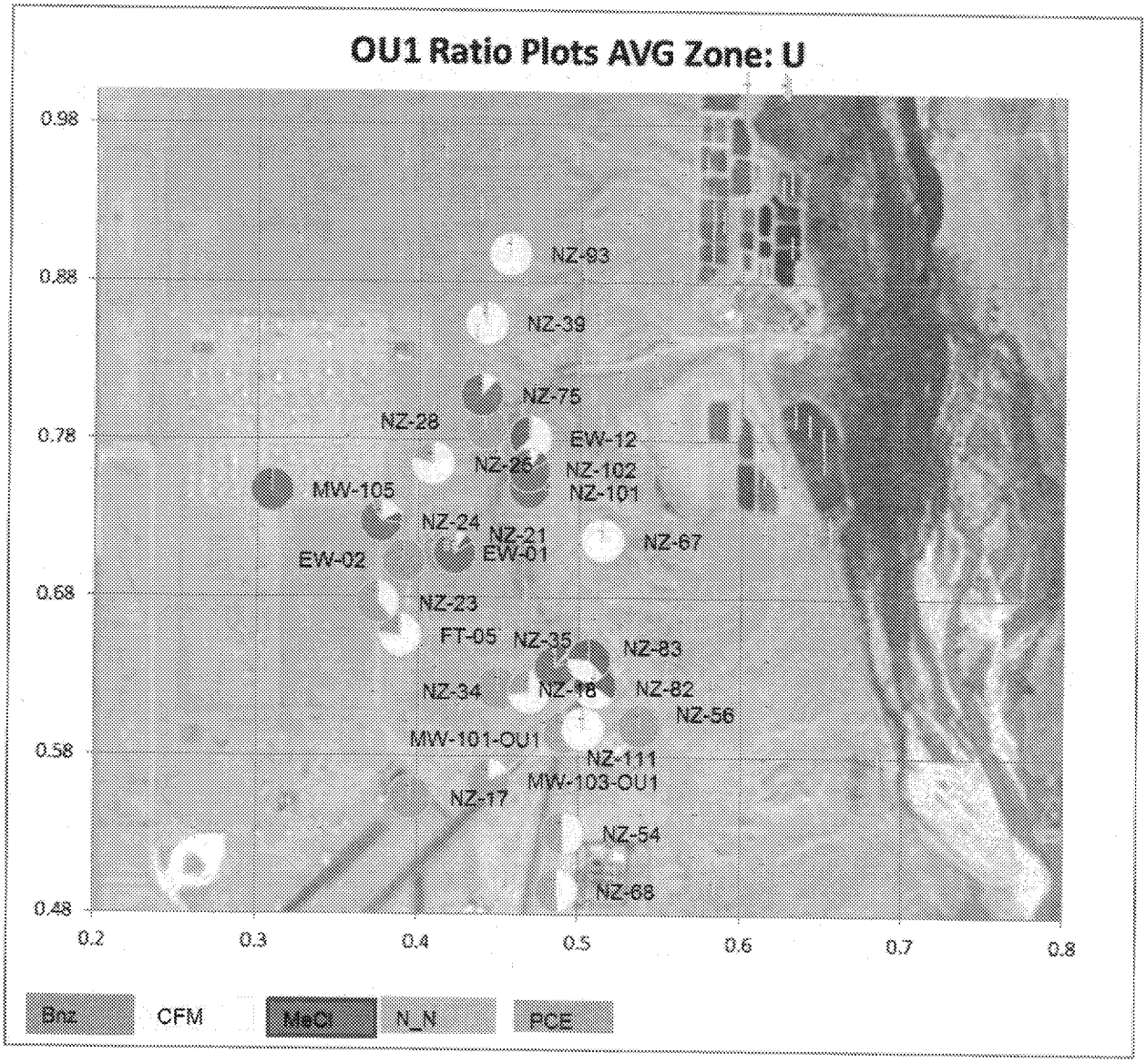
21. 3.2.1 Historical Source Areas. First bullet. The discussion should note that PCE is an indicator parameter for sources at the ISD, FT082, the Arroyo, and the STP source areas. PCE in the Upper Aquifer follows the storm drain to the Arroyo, then follows the Arroyo north. PCE southeast of the STPs moves down and east towards the river. PCE in the Lower aquifer originates east of the STPs where it drops down vertically from the Upper Aquifer and then migrates north. The Tech Memo and the CSM should be revised to reflect the complex history of releases as pulses for various source areas.

22. 3.2.1, Second bullet. In addition to TCE, the Upper Aquifer wells surrounding the STP ponds also have nitrate and low concentrations of PCE, and GSU used the combination of TCE, nitrate, and PCE as a tracer to differentiate plumes that originate beneath the STP ponds and FT082 from plumes originating at FT019. For example, NZ-17's initial sample (1987) had significant TCE and a low detection of PCE, indicating that the VOCs likely

came from FT-082. The Tech Memo and the CSM should be revised to reflect the complex history of releases as pulses for various source areas.

23. Source of TCE in well FT-05: TCE pulses in source areas occurred when water elevations were between 2715 and 2725, most commonly at elevation 2720. This corresponds to a depth of about 115-124 feet. (At some wells (see NZ-46), there was also a pulse when water levels were at elevation 2710.) The boring logs for NZ-110 show this interval contains moist silts and clays, including a note about 'white speckles' suggesting a buried soil horizon with caliche. The boring log for FT-105 does not have sufficient detail to show the speckled layer. The CSM should be revised to reflect the pulse mechanisms and the potential for future releases from the sources.

24. Differences within the plume, and between the Upper, MLU, and Lower Aquifers, are best illustrated with pie diagrams. The following illustrations show, for average values for the period of record, the ratios of five tracer compounds. (average values were used instead of maximum values to prevent outliers from overwhelming the pies) The compounds were chosen to illustrate the extent of water originating from the STP ponds. Evidently, chloroform was present in discharges to the STP ponds, along with nitrate. Methylene chloride is a degradation product of chloroform, and nitrate will support this degradation. In the Upper Aquifer, there is mainly chloroform. In the Lower Aquifer, where nitrate is present, some of the chloroform is transformed to methylene chloride.


OU1 Ratio Plots AVG Zone: U
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0.78
0.68
0.58
0.48
0.2
0.3
0.4
0.5
0.6
0.7
0.8
NZ-93
NZ-39
NZ-75
NZ-28
EW-12
NZ-26
NZ-102
NZ-101
MW-105
NZ-24
NZ-21
EW-01
NZ-67
EW-02
NZ-23
FT-05
NZ-35
NZ-83
NZ-34
NZ-16
NZ-82
NZ-56
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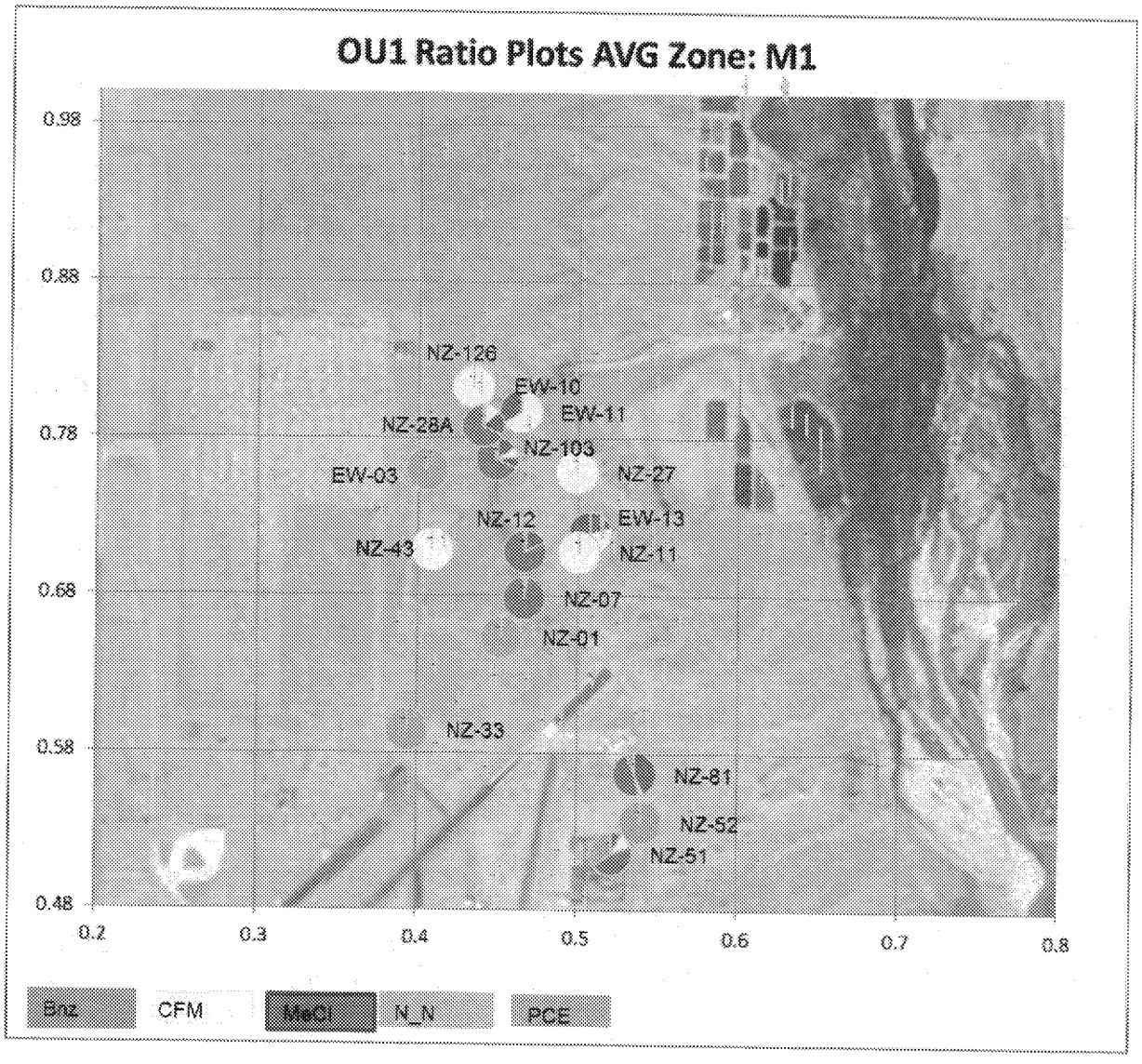
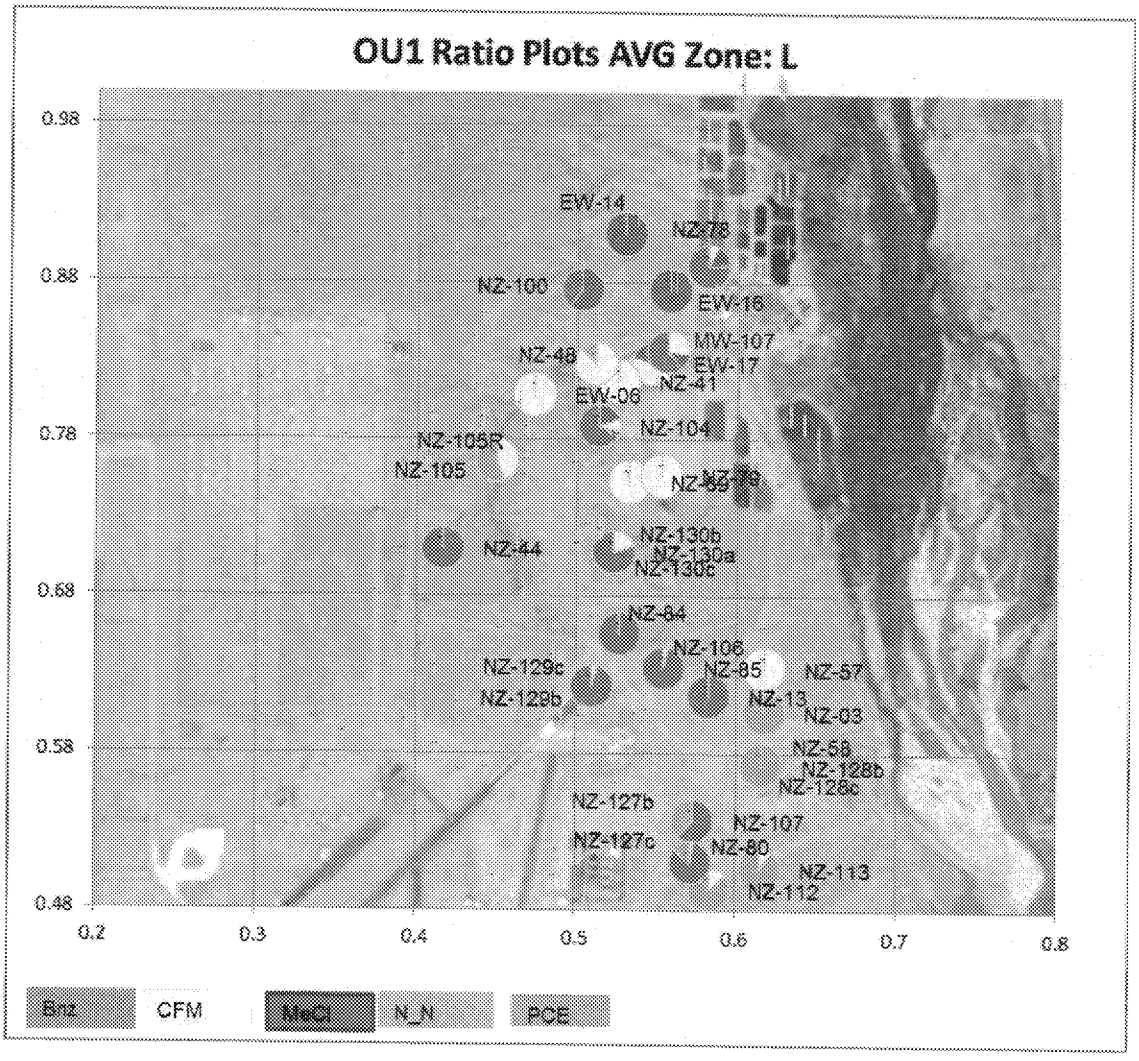


The upper portion of the MLU, M1, has an interesting pattern of methylene chloride (a breakdown product of chloroform) that may have degraded when it mixed with BTEX (possibly originating near NZ-81). The source of chloroform may be FT083. Methylene chloride is found near EW-13 and EW-11. This figure also shows that the PCE source near NZ-52 is distinct from the ponds themselves, because it is not associated with nitrate.

The next figure shows minor VOCs in the Lower Aquifer:

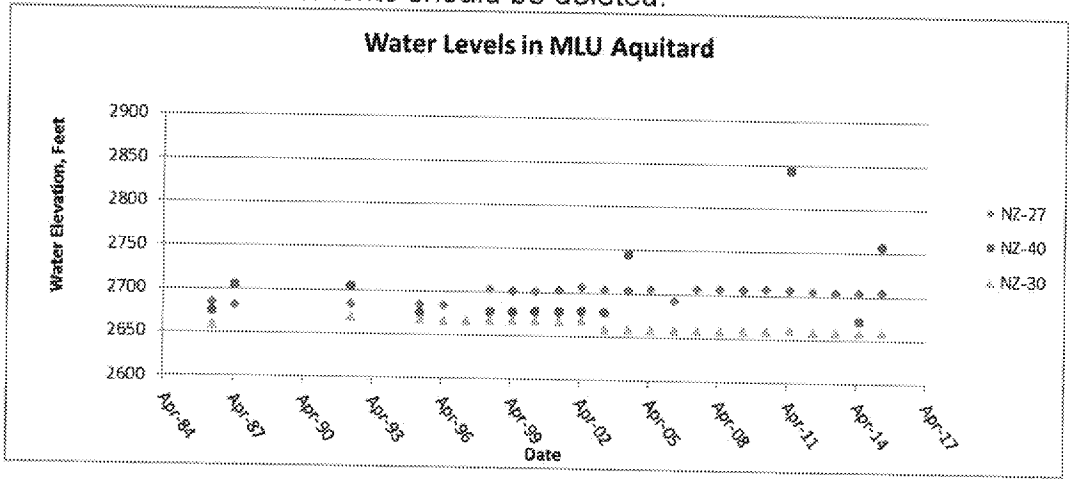


Near the northern VVWRA ponds, there is transformation of chloroform to methylene chloride, probably because of the low redox found near the ponds. Note also the PCE plume south of the southern VVWRA ponds. The rise in nitrate concentrations at NZ-80 and NZ-112 is not being caused by interception of vadose zone nitrate by rising groundwater. It is caused by a change in groundwater flow direction, and movement of the plume to the west. The text should be revised.

25. Section 3.7.1 Upper aquifer plumes. The plume definitions lack precision. As described above, the two different fire training areas have distinct plume signatures that persist as the plumes move in the Upper Aquifer, and can often

be distinguished in the lower aquifer. The FT019 plumes do not have nitrate. The FT082 plumes generally have nitrate. Plumes with source areas near the STPs have nitrate, and also have PCE. The entire section needs to be revised and the analysis needs to identify separate source area plumes. Plumes were propelled by mounding and pumping, and different plume episodes were driven by mounds in different places at different times, and reached different places in the northeast quarter of the base as a result. The Tech Memo and the CSM should be revised to reflect the complex history of releases as pulses for various source areas and changes in flow directions.

26. Water level data quality is unusually poor. There are far too many retained errors, particularly, water levels above or below the physical casing, which should be weeded out. In particular, the MWH FFS Appendix B states that NZ-30 appears have water levels equal to the base of the casing since 2003, and this has never been checked, because water levels are still being reported for the well and used on maps. The well may be perforated across two separate layers in the MLU and the water in the bottom cap may be water that is leaking down the casing. The well has presented difficulties in contouring since about 2003. GSU has a corrected version of the water level dataset available, except for NZ-30. NZ-30 should be sounded and its depth measured, and if the water is just in the cap and not in contact with the aquifer, the well is dry, and all the erroneous measurements should be deleted.

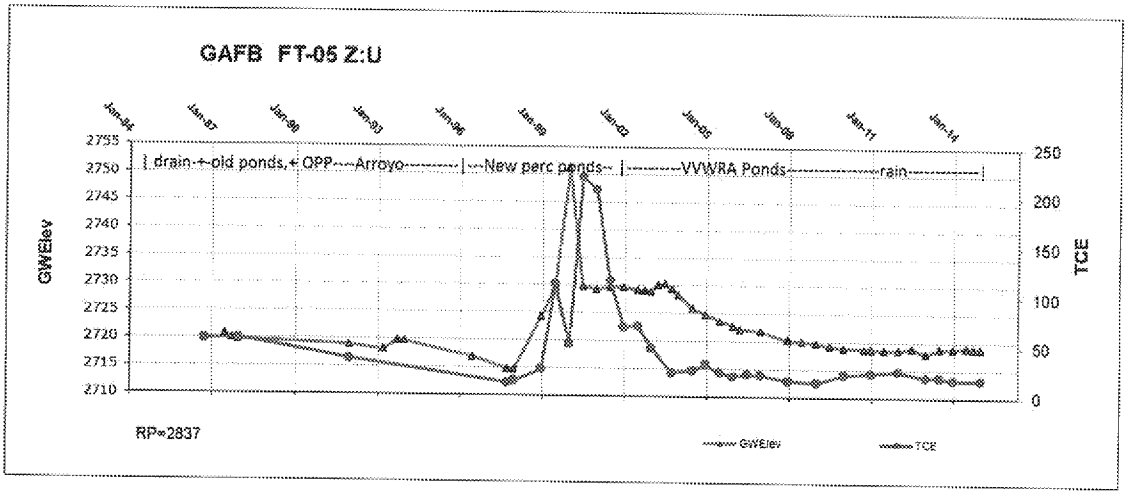


27. Section 3.7 Plume Stability. The Lower Aquifer plume cannot be said to be stable, the plume is currently mainly trapped by groundwater mounds along the River, and is migrating west and north, with a portion escaping around the southern VVWRA mound to the river near OW-1. NZ-80 shows evidence of the change in plume direction, with the FT082 TCE plume moving in from the north. The signature of the FT-82 plume is PCE and nitrate from near the STP ponds.

The Lower Aquifer plume has an eastward breakout at OW-1. The Tech Memo should be revised to discuss these changes in plume migration and potential threat to the Mojave River and the FPA.

28. Section 3.8. The question of where the TCE is going is interesting, but it is not satisfactorily answered in this report. The TCE plumes were generated by recharge reaching source areas, moved under the influence of recharge mounds and pumping, and they are still being displaced by changes in groundwater management as modified by geologic structures. Each plume has had a different history depending on when and where it originated, and where groundwater recharge mounds were placed. What the Tech Memo refers to as TCE decay is actually TCE decrease in wells because of changes in plume location. The Tech Memo should be revised to describe and consider these factors on contaminant trends in wells.

29. Section 3.8 item 3. The time series plots for the fire training wells shows that TCE was mobilized when groundwater levels reached elevation 2720 in late 1998. TCE concentrations at FT-05 are less than 25 ug/L when groundwater levels are lower than 2720. The main source, therefore, is between about elevation 2715 and 2720 in low-conductivity material within a path of high resistance. The FT019 Supplemental Site Investigation Report did not obtain any samples below about elevation 2720. Groundwater is currently just below elevation 2720, and TCE is still present in groundwater at about 18 ug/L, indicating there is still source material present. The FT019 remediation concentrated on source material mainly above the highest groundwater elevation recorded at FT-05, which was no greater than 2750. However, contaminants located higher than elevation 2750 did not contribute to the groundwater plume. Soil remediation has had no effect on TCE in groundwater. It is not clear that the main groundwater source for the FT-019 plume has been discovered, much less remediated, since the source material is under water, below elevation 2720, and is trapped in low-conductivity silts, and cannot be removed by vapor extraction. The Air Force should propose addition measure to address these areas of deep contamination.



30. Residual mass in MLU and vadose zone: The analysis in the TM stated that volatilization would remove a substantial fraction of the VOCs during the drop from the MLU/PLZ to the lower zone. This conclusion conflicts with the groundwater model discussion in the 2005 GWCSM which stated that moisture content in the lower vadose zone was high, and had little capacity to transmit gas. The model essentially treated the lower vadose zone as saturated, but with low transmissivity, from the point of view of groundwater transport. GSU ran three-phase partitioning calculations to estimate the concentrations of gas in equilibrium in the lower zone. The low organic carbon fraction means that volatilization is limited only by available pore space. The estimated concentration of TCE in the lower vadose zone was about 20,000 ug/cubic meter. No samples of lower vadose zone gas have been obtained and analyzed, so the assertion that the TCE is lost to volatilization cannot be verified. However, as described above, volatilization is not needed to account for the 'missing' TCE, the 'missing' TCE is still in the Lower Aquifer, trapped behind the VVWRA mound. Therefore, the Tech Memo does not *demonstrate* contaminant loss through volatilization in the lower vadose zone.

31. Chloride. Chloride can be used as a tracer for several types of sources. The burn pits at the fire training areas are one source of chloride, and evaporated cooling or irrigation water is commonly another. Chloride is not associated with the STPs, but it is associated with evaporative processes like cooling water, and it is notable that some of the highest chloride is just downgradient of the new powerplant (at NZ-51 and NZ-52), which has just showed up in the wells in 2015. It has already reached the Lower Aquifer near NZ-112. The high chloride water should be investigated, because any water being released into the Upper Aquifer has the potential to resaturate old source zones.

32. Section 3.8 item 8. Sorption in MLU: Contamination at George proceeded in a series of local events, not one single event. A large TCE pulse was already present in in the early 1980s, extending from the Fire training area areas to the northern VVWRA ponds. This pulse remobilized when the Arroyo was used for groundwater discharge in 1990, along with the STP and NP ponds which were activated in 1991 and 2003. The GETS water disposal first mobilized contamination at FT082, then when spreading changed to the NP ponds in 2003, activated contamination near FT019. Wells newly installed in 1987, in the PLZ and MLU, were already contaminated, suggesting that the MLU was already holding as much TCE as it could, because each subsequent pulse was transmitted to the Lower Aquifer instead of being sorbed. No additional sorption in the MLU should be assumed.

33. Item 8. The porosity assumption is questionable, because the lower vadose zone does not directly communicate with the atmosphere, and as a result is likely above field capacity, but below saturation. 35% usable porosity is unreasonable for weathered Pliocene deposits, which would have a very low bulk density. Likely the porosity was taken from either USDA tables, which are for plowed fields, or from the FPA study, which are sampled Holocene material in the floodplain. The previous comment applies to this calculation, too: the 1985 pulse had already moved out to the Lower Aquifer, and there was likely no additional capacity to volatilize TCE in the lower vadose zone. In any case, water moving through the lower vadose zone would simply re-dissolve TCE, negating much of the volatilization. The MWH supplemental investigation stated that volatilization in the lower zone was likely small, and GSU agrees.

34. Item 7, Item 8. Volatilization as an argument for missing TCE in Lower Aquifer: GSU calculated volatilization loss using a three-phase partitioning model, which calculates equilibrium concentrations between soil matrix, soil gas, and groundwater. The calculation assumed a plume 500 feet by 500 feet, with a 2-foot source layer in the lower MLU, a 125-foot vadose zone, and a 25-foot Lower aquifer. The soil matrix source was assumed to have a concentration of 0.005 mg/kg TCE. After partitioning among the three phases, the source had 118 grams in soil, 870 grams in soil gas (20,000 ug/M^3), and 1184 grams in groundwater (concentration 56 ug/L). Once the system reaches equilibrium, no further VOCs can be lost to volatilization. Note that this calculation assumes the lower vadose zone soil is at field capacity, which as MWH states, is unlikely where the lower vadose zone is beneath the MLU. Since the soil gas mass is linearly related to available dry porosity, the mass in soil gas is reduced as the wetness of the lower vadose zone increases. The point of the calculation is to show that if volatilazition is the mechanism for mass loss between the MLU and the Lower Aquifer, then TCE should be readily measurable. No measurements

of soil gas below the MLU have been produced to document the claim that volatilization is a major mechanism of attenuation.

35. Many groundwater and gas flow calculations require mechanical analysis of soil, but soil data have only been collected in the Floodplain Aquifer area near the VVWRA ponds. There are no mechanical analyses available near the burn pits, or in the source areas. While there are some piezocone data for the upper vadose zone, there is no data in the lower part of the Upper Aquifer, the MLU, the PLZ, or the Lower Aquifer where it is overlain by the MLU. The lack of actual data means that all the mathematical models used, except TIN, rely on assumed values of porosity and effective porosity. Estimating modeling parameters increases the uncertainty an unknown amount, but it is likely large. The report should discuss the uncertainty in the many estimated parameters used in calculations.

36. Section 4, plume definitions. The report does not separate the different plumes and sections of plumes. Pie diagrams (ratio plots) are very useful for identifying both separate components of the plume, and locations where biodegradation is or is not taking place, and suggesting why it takes place in some places but not in other places. The plume migration discussion would be improved by identifying parts of the plume with different origins. Better understanding of plume subareas would also help in remedy selection.

37. 4.2.1 Destructive attenuation processes, either degradation or volatilization, have not been demonstrated, particularly in the Lower Aquifer. Time series were used to show declines by dilution and diffusion, but the rates are higher than the exponential model predicts, and even this mechanism is uncertain. Concentration decreases due to shifting of the location of the plume have not been distinguished from dilution or volatilization. Water level increases from spreading in the Lower Aquifer can be shown to have changed flow directions and have shifted the plume. The inability of the exponential decay model to account for the rate of decay is further evidence that decay is not the correct mechanism for declines in concentration. The sections on natural attenuation need to be revised.

38. 4.2.1 The study did not identify changes in flow direction caused by spreading or cessation of artificial recharge as a condition making attenuation difficult to prove. While the monitoring network can detect changes in concentration and water levels, understanding what the changes mean is just as important as detecting changes in environmental conditions.

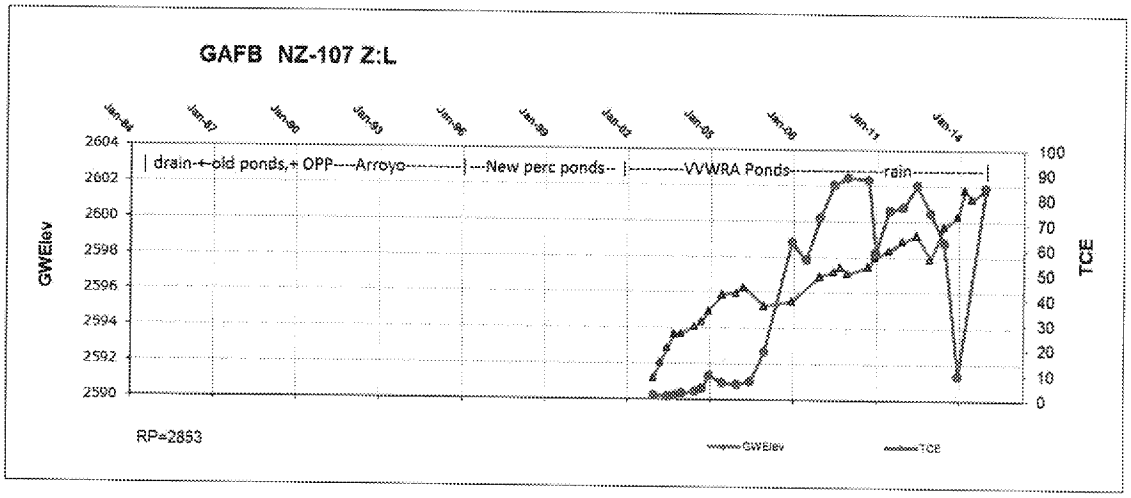
39. 4.2.6 More detailed analysis of time series data has identified water level changes associated with both wet-winter recharge in the Arroyo, and recharge beneath the flightline's storm drain system. It is not clear that no new releases can occur, particularly because it is not clear that all the source material has been removed, particularly from the capillary fringe and upper few feet of the saturated zone.

40. 4.2.7 Institutional controls are not a substitute for preventing infiltration of water into the subsurface. Examples of problems with institutional controls at the former base include the following: The recent finding that the pond near the water tower and by the golf course is actually in use, and overlies a large groundwater mound centered beneath the pond, suggests that institutional controls are not sufficient to prevent accidental releases of water to the subsurface. The mound is spreading the dieldrin plume. There is evidence that the two Prison wells are locally draining the Upper Aquifer in to the Lower Aquifer through their gravel packs, and spreading the benzene plume associated with the fuel tank farm, and preventing the dieldrin plume from reaching the production wells. An additional finding during review was two wells downgradient of the new power plant having elevated chloride concentrations consistent with loss of cooling water to groundwater. Lined ponds eventually leak, and impoundments near sources of contamination need aggressive leak checking and monitoring. Finally, there is no institutional control proposed for the cessation of spreading in the southern VVWRA pond. Loss of this groundwater mound will probably cause the Lower Aquifer plume to flow east towards the River. Reliance on ICs at this complex site is not adequate to prevent further contaminant migration and threats to human health and environment.

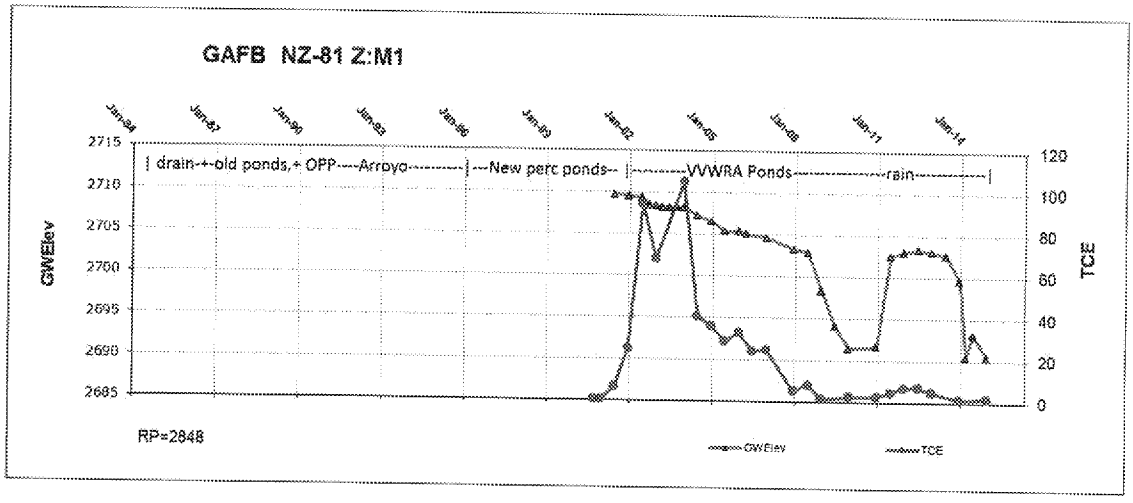
41. Section 5, Meaningful groundwater concentration trends. As stated above, concentration trends at a well are only meaningful if the groundwater flow direction never changes. Particularly in the Lower Aquifer, groundwater flow directions have actually reversed near the VVWRA ponds. Wells located where groundwater flow directions have changed cannot be used for concentration trend calculations because changes in flow direction moves the plume away from the wells, so the time series plot represents different water sources. The discussion states that concentrations decline faster than predicted, but there is no discussion of possible causes. Changes in groundwater flow direction also affect the plume stability discussion, because when groundwater flow direction changes, what appears to be stability may mask redistribution of the plume in a different direction, or backtracking of the plume. Time series charts and maps showing plume stability can only be evaluated in the light of groundwater flow directions, but changes in groundwater flow direction occur with time, and there

are often no wells in new downgradient directions. The Tech Memo does not adequately incorporate and evaluate these factors.

42. Section 5, Concentration Trends. The last bullet on page 5-2 states that increasing TCE trends in Lower Aquifer well I NZ-107 are due to entrainment of vadose TCE. MWH, in Appendix B of the FFS, states that NZ-84's TCE increase since 2002 was because of low attenuation, since NZ-107's TCE was 129 and the Lower Aquifer at NZ-84 was 47. Since the time the FFS was written, TCE concentrations have continued to increase in both wells, along with rising water levels. The wells are, however, not an upgradient-downgradient pair. NZ-84 has only one nitrate detection and no PCE detections, so they cannot be from the same source. Lower Aquifer well MW-107's contamination must have come from a nearby Upper Aquifer well that also has traces of PCE. The candidate source well must have concentrations higher than NZ-107 and contain PCE. More likely, spreading in the STP ponds pushed contaminants southwest of the ponds.



NZ-81 is a candidate for a source for NZ-107. It has the double peak in TCE and also has nitrate and PCE detections, and is in a favorable location. Concentrations of TCE are only a little higher than at NZ-107, which shows very little attenuation. The lack of attenuation is consistent with the steep slope in the Upper Aquifer contours nearby, indicating the MLU is absent near NZ-81.

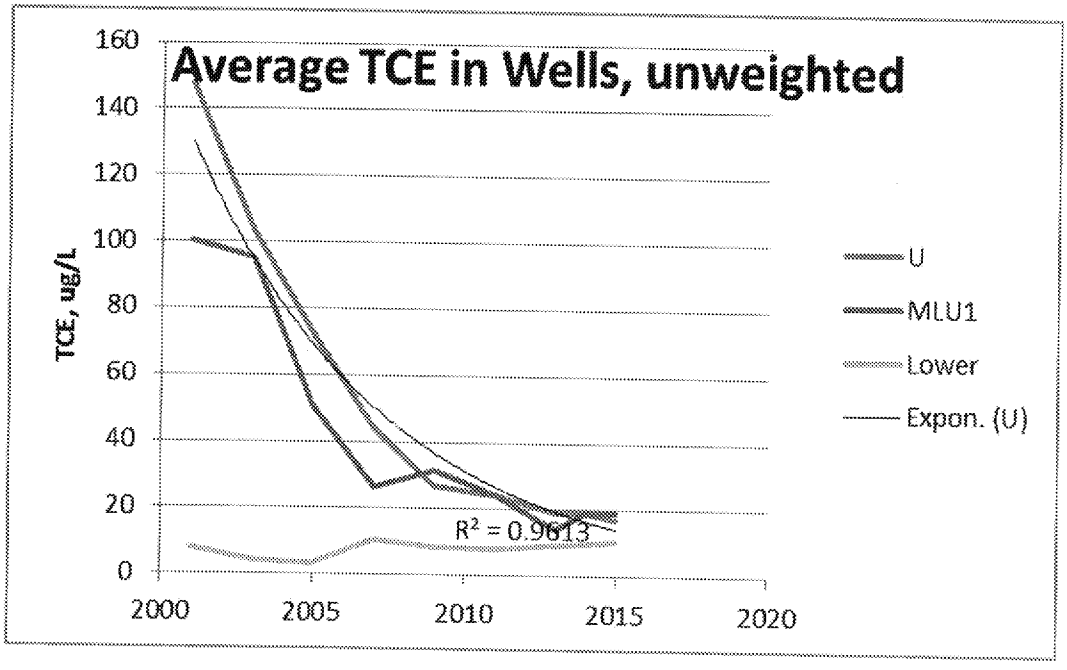


Travel time between the wells is about 5 years, and they are about 738 feet apart horizontally, so the indicated velocity is 0.33 ft./day or 122 ft./year. However, the groundwater gradient at NZ-107 has changed because of spreading since 2002 at the VVWRA ponds, and the gradient at NZ-107 is now to the southwest, not to the northeast as it was when contaminants left the Upper Aquifer. So the pulse may double back and repeat in reverse over the next few years. There are insufficient Lower Aquifer wells west of the Arroyo to monitor westward migration of the TCE plume. The changing flow directions mean that upgradient and downgradient wells change with time, and the Memorandum does not correctly identify the current upgradient and downgradient wells for the Lower Aquifer.

43. The document uses exponential decay as the model for concentration decline, but notes that the declines often happen faster than predicted, and fits to an exponential model generally do not meet EPA criteria for a significant fit. Exponential fits to concentration declines implicitly assume that the well is still, in fact, in the plume. Figure 3-4 of the Tech Memo shows an attempted fit between TCE concentrations and an exponential curve at two wells, but the curve does not actually fit the slope of the peak, nor does it fit the rapid decline of TCE. When an exponential curve does not fit the data, the decline is unlikely to be caused by an exponential process. Near the source areas, the curves fit a pulse source decay model. Near the VVWRA ponds, the concentrations at many wells decline abruptly and the decline coincides with increases in water levels. This suggests that the plume simply changes direction and that the plume is being pushed away from the well and, therefore, the well is not in the plume. This both accounts for TCE's abrupt decline, and invalidates the calculation of attenuation. Many Lower Aquifer hydrographs show the same abrupt TCE decline coinciding with an increase in water levels just after the ponds went into operation. Declines in concentration caused by a change in flow direction do not equal attenuation, and wells with such abrupt declines

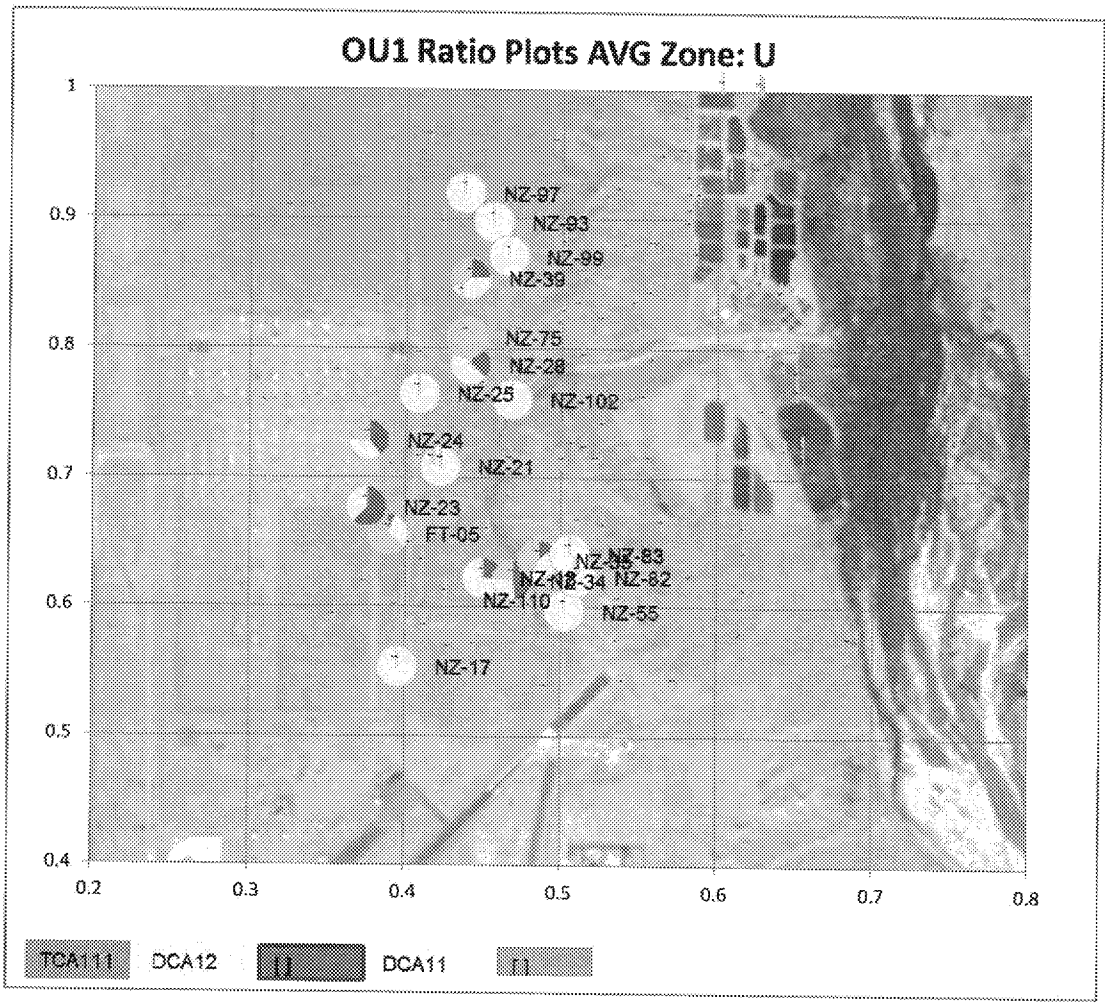
must not be used to calculate attenuation rates. NZ-23, for example, closely fits a pulse decay model, but TCE concentrations at NZ-83 are obviously affected by pumping and recharge, and the trend is a poor fit to the exponential decay assumption.

44. Attenuation between the Upper and Lower Aquifers. The following figure was prepared by averaging maximum TCE concentrations for each year between 2000 and 2015, for the Upper, MLU1 (upper MLU), and Lower Aquifer. An exponential fit was made to the curve, and shows a highly significant fit for the Upper and MLU, indicating that the latest VOC pulse is drying out, with the most probable mechanism being collapse of the mounds in the Upper Aquifer and subsequent reduction of drainage into the MLU and Lower Aquifer. Lack of cis-1,2DCE shows that degradation is not occurring. The poorer fit in the MLU is likely caused by both delayed drainage from the Upper Aquifer and its lower hydraulic conductivity. The Lower Aquifer TCE concentrations do not show any decline in averaged peak concentration, and there is a slight rising trend. The concentrations show practically no attenuation between the Upper Aquifer and the upper MLU, which would be expected if there is no loss by decay. The lowest part of the MLU has the lowest hydraulic conductivity, and the low rate of leakage to the Lower Aquifer is consistent with the slightly increasing trend in the Lower Aquifer. This low rise suggests a very low rate of TCE mass movement into the Lower Aquifer.



45. VVWRA ponds are currently preventing Lower Aquifer contamination from reaching the Mojave River. When spreading ceases, the Lower Aquifer flow directions will revert to the pre-2004 flow directions, i.e., toward the Mojave River. The document needs to address the impact of changes in plume migration when the VVWRA spreading mound drains away. The document implies that the plume will have attenuated by then, but increasing concentrations in westward-flowing parts of the Lower Aquifer suggest that, when the mounds go away, the Lower Aquifer will move the plumes back toward the River.

46. Attachment 7. Abiotic degradation. A paper describing abiotic degradation rates, found in the EPA Reactive Minerals paper in Attachment 7, was offered to support the proposed rapid degradation of TCE. The rates in the paper are unpersuasive, both because the rates are far too high, and because they do not appear to apply to TCE degradation, and for the compounds to which they do apply, the rates described are not observed. The solvent plumes are many years old, in some place for over 40 years. The cited reaction rates occur in days, which would suggest either that the initial concentrations were near free product levels, or the plume should have dissipated years ago. The lack of degradation products (cis- or trans-1,2 DCE) in the Lower Aquifer suggests that essentially no TCE degradation, either abiotic or biological, is occurring. (However, abiotic biodegradation of 111-TCA is shown by decreasing TCA and increasing increasing detections of DCA since 1986. 111-TCA degrades abiotically, so the conversion of TCA to DCA indicates aging of the TCA. The ratio plots below shows how TCA is mainly found near source areas and in the Upper Aquifer, and 1,2-DCA and 1,2-DCE are mainly found in the MLU and Lower Aquifer/FPA.) If TCA degradation is observable, then TCE degradation should also be observable. The relevance of the abiotic degradation reference needs to be clarified or the reference removed.


OU1 Ratio Plots AVG Zone: U
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0.4
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0.8
NZ-97
NZ-93
NZ-99
NZ-39
NZ-75
NZ-28
NZ-25
NZ-102
NZ-24
NZ-21
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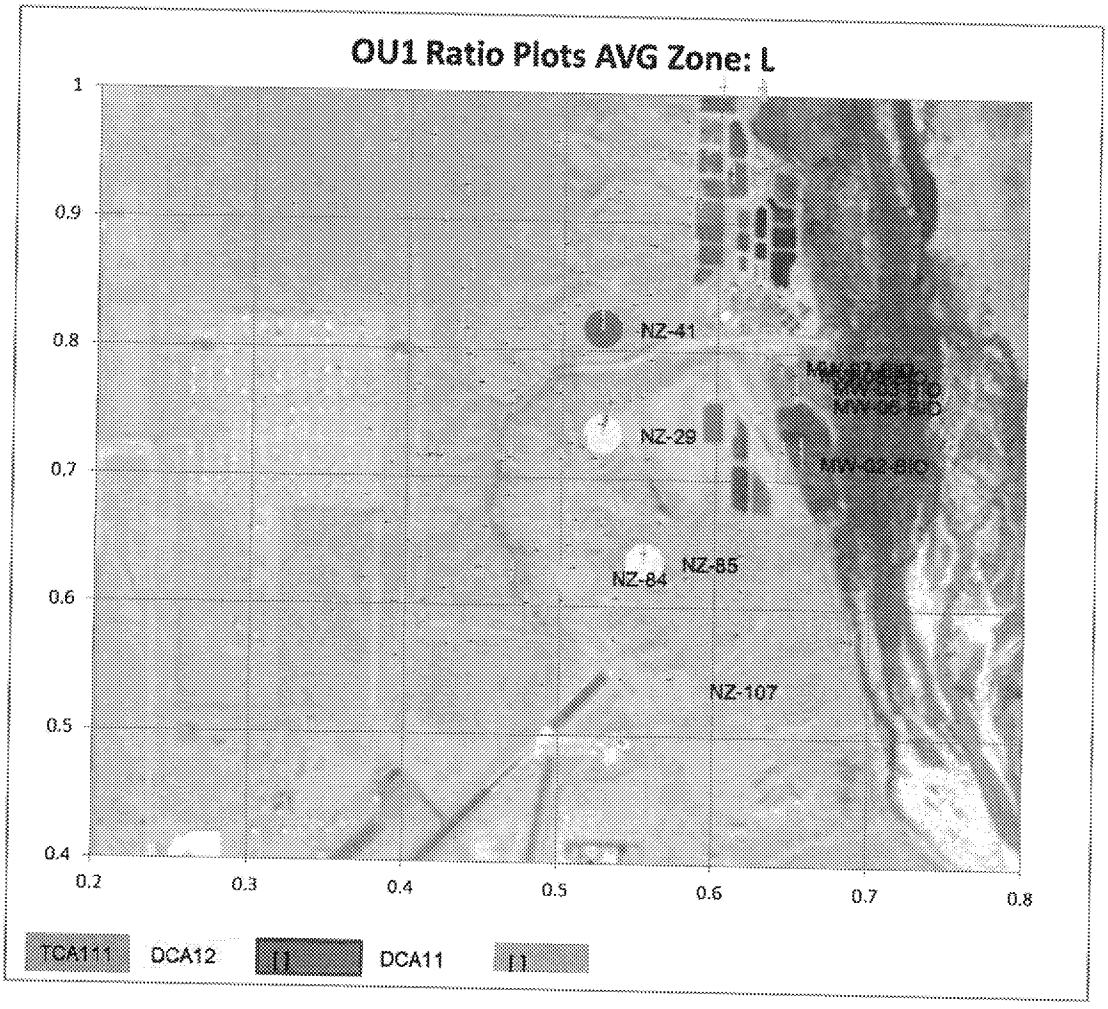
TCA111
DCA12
DCA11



The presence of undegraded 111-TCA near the Northern VVWRA ponds shows 111-TCA must have been discharged into the Arroyo, because it reached the ponds too soon to have traveled by groundwater flow. Having three different flow paths for VOC migration makes untangling the history of contamination at any one well very difficult. While these are not COCs, they do help show the extent of the different plumes and their subsequent migration.

47. Attachment 6 section 1.5. The simplest way to find out whether anaerobic biodegradation of TCE is occurring is to look for cis-1,2-DCE or vinyl chloride. Vinyl chloride has not been detected in groundwater at FT-05, or at any other FT well. It is detected in a few Lower Aquifer wells near the VVWRA ponds in the following wells: NZ-100, NZ-104, NZ-131c, and NZ-76. Some of these wells also have cis-1,2-DCE. GSU agrees there is little biodegradation at

George, but notes that biodegradation can occur at George, but does not because of a lack of nutrients and organic carbon.

48. GSU concurs that there is little evidence of biodegradation, but disagrees with the implied conclusion that biodegradation cannot occur. TCE daughter products occur where nutrients and organic carbon occur, and one should not conclude that lack of intrinsic biodegradation means enhanced degradation cannot be used to reduce concentrations in the Lower Aquifer.

49. Attachment 6 section 1.5, and section 1.7, Summary. The list of decline mechanisms should also include movement of the plume away from the well.

50. Institutional Controls: The plumes at George are driven by infiltration of water that pond in discrete areas as discussed above. Several of the above comments describe locations where recharge pulses are still being generated by wet winters. Old recharge ponds need to be filled in, capped, and graded to drain. Surface impoundments need leak detection monitoring and need to be repaired when leaks are found. The Power plant needs to monitor for leaking cooling water.

51. Continuing VOC impacts in groundwater in source areas, and the lack of improvement after SVE, shows that source material remains in place, probably in the uppermost part of the saturated zone, below the reach of the SVE systems. Additional sampling in source areas is needed to locate the remaining source material, and source material needs to be treated or removed once it is found.

Conclusions and Recommendations:

1. Institutional controls are insufficient to prevent plume initiation and migration.

2. Insufficient evidence has been presented to show that source areas have been cleaned up, particularly the uppermost saturated zone.

3. GSU finds that there is little evidence of off-gassing or abiotic degradation in the Lower Aquifer.

4. GSU does not find evidence that overall concentrations are declining in the Lower Aquifer.

5. GSU finds the calculated and estimated rates of degradation are technically unsound, unreasonably short, and do not account for the most probable mechanisms of concentration decline, e.g, plume migration away from wells.

6. GSU finds that there was little analysis of potential uncertainty in rates, particularly, uncertainty due to estimated porosity and conductivity data.

7. The attenuation rates use an unrealistic model of degradation (exponential decay). Exponential lines were fit to portions of the TCE time series with obvious increases in groundwater levels that may have deflected the plume away from the well.

8. GSU recommends the report not be accepted.

Questions regarding this memo should be directed to Ms. Alice Campbell by contacting her at 818-717-6623 or acampbel@dtsc.ca.gov.

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DRAFT TECHNICAL MEMORANDUM EVIDENCE FOR NATURAL ATTENUATION, OPERABLE UNIT 1, CG070, FORMER GEORGE AIR FORCE BASE, VICTORVILLE, SAN BERNARDINO COUNTY

Introduction

The Lahontan Regional Water Quality Control Board (Water Board) received the *Draft Technical Memorandum Evidence for Natural Attenuation Operable Unit 1, CG070, Former George Air Force Base* (Tech Memo) on May 11, 2015. Water Board staff reviewed the Tech Memo and finds that it does not provide an adequate demonstration that MNA at Site CG070 will meet Water Board requirements. Based on staff's evaluation of the Tech Memo and existing data, the time to achieve the maximum contaminant level for trichloroethene is most likely closer to the 500 years predicted by the 2012 OU1 Site CG070 Focused Feasibility Study's (Focused FS) than the 80 years stated in the Tech Memo. Therefore, additional active remediation of CG070 is required before the Water Board can consider reliance on MNA.

2012 OU1 Site CG070 Focused Feasibility Study's (Focused FS) analysis, which predicted that the monitored natural attenuation (MNA) remedy would require 500 years and 20 million dollars for trichloroethene (TCE) in groundwater to be cleaned up to the maximum contaminant level (MCL) of 5 micrograms/liter (µg/L) and 600 years and 22 million dollars to reach the background concentration (i.e., detection limit of 0.5 µg/L).

The Air Force proposed MNA with Institutional Controls (ICs), as its preferred remedy in the February 2014, *Final Revised Proposed Plan for OU1, Site CG070 Record of Decision Amendment* (Proposed Plan). Since the issuance of the Proposed Plan, the Air Force has maintained that there is new information regarding TCE degradation in site groundwater and that the new predicted timeframe for reaching MCLs at OU1 Site CG070 is much shorter than the 500 years reported in the Focused FS. The purpose of the MNA Tech Memo is to provide the Air Force's technical evaluation supporting the shorter timeframe to achieve MCLs. The following text and enclosures 1 and 2

delineated why the Water Board cannot accept the Tech Memo as an adequate demonstration that the proposed remedy of MNA meets Water Board requirements.

Comment 1: Section 2.0 Background

This section provides a good summary of the historical documents supporting the remedial optimization effort for CG070. This information helps provide an appropriate framework for the Tech Memo. The text under the heading "Site History" should be expanded regarding the OU1 Record of Decision (ROD) and the groundwater extraction and treatment system (GETS), locations of extraction wells and areas of discharge of treated groundwater including the discharge to the new percolation ponds. The period of operation for the extraction wells and discharge areas should also be included. The location and time of the discharges are especially critical to understanding the plume behavior and must be considered in the evaluation of trends. Also see Enclosure 1, Comment 11.

Comment 2: Section 3.1, Hydrogeology

Water Board staff disagrees with the statement that the source of TCE in a Flood Plain Aquifer wells in the vicinity of Victor Valley Wastewater Reclamation Agency (VVWRA) plant, is uncertain. Historically, the MCL boundary of the CG070 the plume extended into this portion of the Flood Plain Aquifer. The maximum TCE detected was 17 µg/L in Flood Plain Aquifer well, LW-2, in 1994. The leading edge of the plume (as delineated by the MCL) was largely pulled back by the operation of the GETS extraction wells. The the current presence of TCE below the MCL in the vicinity of VVWRA is either a residual from that portion of the plume or continued migration of the Lower Aquifer plume. There are no other known sources for the TCE in this portion of the Flood Plain Aquifer.

Comment 3: Section 3.1, Hydrogeology

This section should be revised to include a discussion of the thicknesses of the Middle Lacustrine Zone/Permeable Lacustrine Zone (MLZ/PLZ).

Comment 4: Section 3.2, Sources

Water Board staff does not agree that there are no remaining contributing sources to groundwater contamination. See Comment 13b, 16, and 17, and Enclosure 1. Additionally, this section states that the soil vapor extraction (SVE) systems in operation at FT019 "are scheduled to be restarted in fourth quarter 2014." Please revise this section to reflect current operation or expected startup dates for the systems.

Comment 5: Section 3.3 TCE Concentrations over Time

The text makes conclusions regarding changes in the size of the plume based on figures 3-2 and 3-3. There are several problems with the use of these figures to support these conclusions, which are discussed in detail under Comment 15 and Enclosure 1, Comment 28.

Comment 6: Section 3.4 Current Nature and Extent of Contamination

This section describes the MLZ/PLZ as "aquifers." The Conceptual Site Model (CSM) and Focused FS classify the MLZ/PLZ as an aquitard. The discussion of hydrologic units should be revised for consistency with the CSM and Focused FS. Also see Comment 29 regarding revising the Tech Memo to reference the regulatory-accepted Focused FS.

Comment 7: Section 3.4, Current Nature and Extent of Contamination

Staff does not agree that there is uncertainty regarding the source of TCE in the Flood Plain Aquifer in the vicinity of VVWRA (see Comment 2). This section should also be revised to reflect the highest TCE concentration detected in the Flood Plain Aquifer wells, i.e., 17 µg/L in LW-2 in 1994.

Comment 8: Section 3.4, Current Nature and Extent of Contamination

The discussion of potential receptors should be revised to address the following issues.

a. Staff does not agree with the assumption that the Mojave River acts as a complete groundwater divide and protects supply wells on the east side of the river (see Enclosure 1, Comment 9).

b. The discussion of water supply needs clarification. The text should specify the well operator/owner and general location of the wells. Note, there are two wells at the VVWRA plant that supply potable water to that facility. These wells are in the Flood Plain Aquifer downgradient of the Lower Aquifer plume. Please confirm these wells are addressed in this discussion.

Comment 9: Section 3.4, Current Nature and Extent of Contamination

This section states the CSM model will be updated periodically to increase the confidence in the predictions. The staff believes that updated CSM is warranted prior to the ROD Amendment (see Enclosure 1, Comment 2, 3, 4, and 6). This update should include current information and empirical data. Note, an MNA remedy must contain clear, regulatory-accepted procedures for evaluating the protectiveness and effectiveness of the remedy.

Comment 10: Section 4.1, Well Network Details

This section classifies selected monitoring wells in accordance with the *Performance Monitoring of MNA Remedies for VOCs in Ground Water* (USEPA 2004). However, the text does not provide rationales for including individual wells in specific classes. For example, it is not clear how FT-04 can function as both a "source zone well" and a "distal well." Also, NZ-107 is classified as a recalcitrant zone well but the text states that recalcitrant zones have not been identified at the site. The CG070 wells should be compiled in a table format with the critical well specifications shown in Table 4-1 of the Tech Memo, current water level data, and the rationale for each well (e.g. source zone well that monitor deep zone of aquifer for vertical delineation) and the justification for USEPA performance classification. Additionally, Table 4-1 is the complete list of all monitoring wells at GAFB. This table should be revised to include only Site CG070 wells.

Comment 11: Section 4.2, Section Well Network Suitability

This section appears to be stating that the existing monitoring network is adequate for MNA performance monitoring. MNA has not been accepted by the Water Board as the selected remedy and the long-term monitoring system for any selected remedy will be developed in the post-ROD, remedial design phase. This section should be revised to acknowledge that a performance monitoring for a regulatory accepted remedy will be developed during the remedial design. However, Water Board staff provides the following comments on this section in the context of whether the existing monitoring system is adequate for an MNA demonstration at CG070.

a. **Section 4.2.1 Objective 1, Demonstrate that Natural Attenuation is Occurring as Expected.** The Water Board staff does not agree that wells are located appropriately to demonstrate that natural attenuation is occurring as expected or that the current monitoring well network demonstrates the CG070 plumes are stable (see Comment 15.d).

b. **Section 4.2.2 Objective 2, Detect Changes in Environmental Conditions that May Reduce the Efficacy of Any of the Natural Attenuation Processes.** The statement that groundwater pumping for the GETS reduced the efficacy of the remedial action is incorrect. There has been no documentation linking extraction of the groundwater to TCE increases during GETS operation. The increase in TCE concentrations in groundwater during GETS operation was caused by the discharge and infiltration of the treated groundwater in areas overlying the central portion of the plume. The infiltration of the treated water mobilized vadose zone contamination and caused the groundwater level to rise into deep vadose zone contamination. The discharge of treated groundwater at one location, the old wastewater ponds, also mobilized nitrate and resulted in a nitrate plume in the Upper Aquifer. Also see Enclosure 1, comments 6 and 7.

c. **Section 4.2.3, Objective 3, Identify Any Potential Toxic and/or Mobile Transformation Products.** The statement that abiotic degradation is occurring at the site is incorrect and is not consistent with other portions of the text and the Focused FS, which state that abiotic degradation is not a significant attenuation process at CG070. The Tech Memo provides no evidence of abiotic degradation.

d. **Section 4.2.4 Objective 4 – Verify that the Plume is Not Expanding Downgradient, Laterally or Vertically.** Water Board staff does not concur with the statement that the CG070 plumes are not expanding and that the existing monitoring network is adequate to confirm plume stability. See comments 13 and 15-17.

e. **Section 4.2.5 Objective 5 Verify No Unacceptable Impact to Downgradient Receptors.** This section should indicate the general location of the supply wells and include the water supply wells located at VVWRA (see Comment 8.b). The text should specify which water supply wells are being sampled annually and reference the supporting data for the statement that annual monitoring at the site has demonstrated that the water supply wells have not been impacted. The text

should also be revised to discuss the surface water receptors as described in the Focused FS.

f. **Section 4.2.6 Objective 6 – Detect New Releases of Contaminants to the Environment that Could Impact the Effectiveness of the Natural Attenuation Remedy**. Water Board staff does not concur with the statement that all sources have been identified and controlled (see comments 4 and 13.a and Enclosure 1). Additionally, many of the monitoring wells have screened intervals that are significantly submerged below the groundwater surface. Submerged screens will delay or miss the identification of releases.

g. **Section 4.2.7 Objective 7 – Demonstrate the Efficacy of Institutional Controls that Were Put in Place to Protect Potential Receptors.** Staff does not concur that the proposed institutional controls (ICs) are protective. See Comment 12.

h. **Section 4.2.8 Objective 8 – Verify Attainment of Remediation Objectives.** Given the long timeframe to reach MCLs and potential for changing conditions, e.g., groundwater fluctuations, changes in groundwater flow directions, complex hydrogeology, and unknown vertical migration pathways from the Upper Aquifer to the Lower Aquifer, it is unlikely that the existing monitoring network will be adequate to demonstrate attainment of remedial objectives.

Comment 12: Sections 4.2 and 6.2 Proposed Institutional Controls

Section 4.2.7 notes that the Proposed Plan identifies land-use controls in the form of Institutional Controls (ICs) that are intended to provide the maximum assurance that the selected remedial action is and will remain protective. It describes a County Notification Zone Process, (Notification Process) that is meant to limit the installation of wells in areas above or in the vicinity of the CG070 TCE plume. However, the Notification Process and the other processes that are identified in the Proposed Plan do not provide a sufficient basis to support that there are adequate ICs in place to protect potential receptors. The proposed "multiple layers" are deficient because they rely upon mechanisms that are not actual legally enforceable rules or ordinances. Lastly, Section 6.2 notes that "if the multiple layers of interlocking governmental controls fail to prevent potential exposure of human or ecological receptors to groundwater," the Air Force proposes to create a Water Supply Contingency Plan. The Plan, which assumes that the Air Force will know about the de minimus user, will supply water to that user instead of their reliance upon contaminated groundwater.

The proposed ICs include zoning ordinances, which can be changed; Consultation Zones, that are unenforceable; a well permitting process that is contingent upon a consultation process with other agencies that relies on those other agencies maintaining an internal processes to identify potentially contaminated areas; and a building permit process that does not have the ability to prohibit the installation of wells based upon their location. Although zoning that limits residential use provides some protection against residential use of the site, it still allows other uses, which could expose workers to contamination if water is being provided by wells on the site. Informational controls such as these are limited in their ability to provide certainty that limits on groundwater

use would be sustainable over time. For the non-Air Force owned properties there are no proprietary controls that one would normally expect, such as a deed restriction. None of the proposed ICs would assure that the ICs would protect potential receptors. This is especially important where, as here, the Air Force wants to rely upon MNA to clean up the site. "In cases where ICs are the entire remedy, special precautions must be made to ensure the controls are reliable." (USEPA, September 2000, *Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups*, p. 3, quoting from the response to comments section of the preamble to the NCP (55 Federal Register 8706 (March 8, 1990)) (hereafter "USEPA Guide to ICs").

ICs need to be evaluated in the same level of detail as other remedy components to ensure their ability to protect human health and the environment. (USEPA Guide to ICs, p. 5.) The layered or series of ICs need to be evaluated to determine their respective strengths and weaknesses and also in combination with the engineered controls to identify the key tradeoffs that should be balanced for the site, including the long-term effectiveness or permanence or reliability. (Id at p. 8.) Long-term effectiveness can be affected by the site being privately owned and changing hands over times; by its being applicable to multiple properties and by the local government's willingness and ability to monitor and enforce the longer-term ICs. (Id.) Where it is required to be effective for a long period, a proprietary or government control should be in place because they generally run with the land and are enforceable. (Id.) Viability over the long-term has to be closely evaluated, and needs to consider whether the entities responsible for implementation possess the jurisdiction, authority, willingness and capability to establish, monitor and enforce ICs. (Id.)

The concern with all of the proposed ICs in the proposed plan is that they are not able to adequately control the installation of wells on the parcels not owned by the Air Force. Although the Consultation Zones could arguably provide information to the proposed well applicant, it is based on a non-enforceable policy, rather than an ordinance, which is enforceable. Such processes are unreliable, and because they are not formalized by ordinance, may be forgotten over the long-term. Similarly, the Water Contingency Supply Plan relies upon an informal consultation process that assumes that the City or County will let the Air Force will know if wells are permitted within the contaminated area; however, there is no legal requirement to do so. "Regardless of which measures are relied on, the land use control should be carefully evaluated to make certain that there are no exceptions which could allow for improper use of the site." (USEPA Guide to ICs, p. 4.)

The State disagrees with the Air Force's assertion in Section 6.2, that the long-term monitoring and ICs will be reliable over long periods of time because the plans are "well understood and accepted practice." The processes that the Air Force is relying upon to ensure that contaminated groundwater is not used for human consumption at the non-Air Force owned properties are untypical, untested, and not reliable. The Air Force needs to rely on standard governmental and proprietary controls such as local ordinances and/or statutes that restrict wells being permitted within the contaminated areas and restrictions on the deeds of the non-Air Force Parcels. Such requirements could be identified in the local ordinances by those who are interested. Similarly,

anyone doing due diligence to find out about any restrictions on the use of the property would normally look not only at the local ordinances, but also at the chain of title of the property. Although establishing ICs with non-source property owners can be difficult and may trigger the need for more complex negotiations, the Air Force must use its "best efforts" to secure any required proprietary controls, which may include compensation by the responsible party to the affected landowners for the proprietary control. (USEPA, December 2012, *Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites*, p. 18-19) (hereafter referred to as "USEPA Guide to Planning"). While implementation challenges are significant, so are the benefits of proprietary controls, such as their enforceability and long-term effectiveness. (USEPA Guide to Planning, p. 17.) Please describe any efforts or discussions by Air Force to secure proprietary controls on the non-Air Force owned sites.

Comment 13: Section 5.1.1 Tier 1 – Meaningful Groundwater Concentration Trends over Time.

Water Board staff does not agree that all the wells that the Tech Memo classifies as "decreasing" show clear decreasing trends. It is also not clear how the Tech Memo determined specific wells had an "indeterminate" or increasing trend since no evaluation is provided for those wells and the Tech Memo plots of data tend to obscure trends (see Enclosure 1, comments 11, 13, and 18). Staff also found that many of the wells that the Tech Memo classifies as decreasing or indeterminate appear to reflect pulses of TCE (see Enclosure 1). To visually evaluate trends, staff regraphed the plots that were provided electronically and identified the following trends and relationships that are not discussed in the Tech Memo.

a. Two Upper Aquifer wells, NZ-51 and NZ-54, have increasing trends. However, the text only acknowledges an increasing trend in NZ-54. Both NZ-51 and NZ-54 are located in the southern portion of the Upper Aquifer plume and may be associated with an unidentified source area. Additionally, FT-01, a source zone well located in the deeper portion of the Upper Aquifer, had a recent spike in TCE, although that data point was not included in the Tech Memo's trend analysis.

b. The three hotspot wells in the Lower Aquifer, EW-6, NZ-84, and NZ-107, show increasing trends since GETS shutdown. NZ-107 appears to have been stable since 2008, but NZ-80, the well downgradient of NZ-107 is still increasing. The TCE increase in the hot spot wells is indicative that there is continuing mass transfer of TCE from the Upper Aquifer and/or MLZ/PLZ to Lower Aquifer. NZ-98 is downgradient of EW-6 and the recent increase in TCE in NZ-98 may indicate additional plume migration (note, the detection of TCE at 7.8 µg/L NZ-98 is shown on Figure 4-2, but this point is not honored in the construction of the 5 µg/L isoconcentration contour.

c. Many of the Lower Aquifer wells with decreasing trends are in the vicinity the new VVWRA infiltration ponds (e.g., NZ-29, NZ-41, NZ-69, NZ-70, and NZ-104). Infiltration from these ponds has caused a groundwater mound and a change in the direction of plume migration. Therefore, the decrease in TCE concentrations

in these wells appears to be the result of the influence of the ponds, not from contaminant decay.

Comment 14: Observed Decreases in Concentrations at Individual Wells.

There are multiple problems with the Air Force's evaluation of TCE trends and calculated biodegradation rates for the CG070 plumes. Therefore, Water Board staff does not concur with conclusions based on these calculations. Specific problems with the analysis are discussed below and in comments 13, 15, and Enclosure 1.

a. The Tech Memo does not include an adequate evaluation of the plume behavior and the factors that influence plume behavior such as GETS startup and operational changes, infiltration events, and changes in groundwater flow direction (see Comment 17 and Enclosure 1). These factors must be considered to determine whether a well trend represents actual decay and can be used to estimate time to achieve cleanup goals or if the trend is caused by factors unrelated to decay, such as a change in flow direction.

b. Only a subset of the data is used to calculate the decay rate for selected wells and the Tech Memo does not provide well specific rationales for excluding data. Frequently, data appears to be selected to best support exponential decay. See Enclosure 1 for a detailed discussion of problems with the data selected for regression analysis.

c. Even though the Tech Memo selectively uses the data that most closely supports exponential decay, the trend analysis shows a generally poor fit with exponential decay. USEPA's 2002 guidance, *Calculation and Use of First-Order Rate Constants for MNA Studies* (USEPA Rate Constant Guidance), states that, to be used qualitatively, the regression correlation coefficient (R^2) must be at least 0.9. Only three Upper Aquifer wells (FT-02, NZ-27, and NZ-94) and two Lower Aquifer wells (NZ-73 and NZ-104) meet this requirement. The Air Force appears to have used trends with regression correlation coefficient that indicate there is no correlation between the data and the trend (e.g., $R^2 = 0.07$ for NZ-93) in the calculation of decay rates (see Comment 13 for further discussion of NZ-93). The poor correlation of the TCE trends to exponential decay is discussed further in Enclosure 1.

d. At least two wells used to calculate degradation rates are wells associated with flightline petroleum sites, including: MW-35 (Site OT069b) and MW-101-OU2 (mislabeled in the Tech Memo as MW-101-OU1), which is also a flightline well. The OT069 TCE plumes are commingled with petroleum hydrocarbons, which have resulted in reductive dechlorination of TCE in that area. Therefore, the degradation rates for these wells are not applicable to CG070 where reductive dechlorination is not occurring at a significant level. Additionally, the regression analysis for MW-101-OU2 only uses four data points to determine the regression coefficient. USEPA Rate Constant Guidance states that it is difficult to extract a rate constant that is statistically significant with fewer than six samples.

e. Many of the Upper Aquifer wells that historically had the highest TCE concentrations (up to 1,200 µg/L), e.g., NZ-40, NZ-55, NZ-82, and NZ-83, have

not been sampled since 2004. The lack of data from these wells may be skewing the data so that TCE declines in the Upper Aquifer since 2004 appear greater than they would be if more recent samples had been collected from these wells. Also, it is inappropriate to include data from NZ-55 to calculate decay rates since TCE data for NZ-55 show that the monitoring well was strongly influenced by GETS operation and only one sample was collected after GETS was terminated.

f. Staff does not accept the Air Force's approach of averaging degradation rates for selected wells. The Tech Memo quotes the USEPA Rate Constants Guidance, as supporting this statement, i.e., "Concentration vs. time rate constants for wells encompassing the entire plume can be used to identify overall trends and predict the duration of the plume." This quote is taken out of context and staff informed the Air Force in the August 2014 meeting that this averaging approach was not acceptable to the Water Board. The USEPA Rate Constants Guidance more specifically states the following under *Concentration vs. Term Rate Constants* on Page 7: point decay rate constants are used "to estimate plume lifetime" by showing the time to reach the remediation goal at the point where the decay rate was calculated.

g. The USEPA Rate Constants Guidance states that, to reduce uncertainty, rate constants based on concentrations versus time and concentrations versus distance and biodegradation rates should be evaluated. In the case of CG070, there is no evidence of biodegradation and there is a significant level of uncertainty regarding the effectiveness of MNA. Therefore, rate constants for both time and distance should have been considered and an uncertainty analysis should have been performed in accordance with Appendix 1 of USEPA Rate Constants Guidance, including calculating the confidence interval on the slope of the regression using a one-tailed test to determine the greatest time to reach cleanup goals.

h. See Enclosure 1, Comment 6 regarding the calculation and use of average values for the three time periods discussed in this section.

In conclusion, the Tech Memo's estimation of timeframe to achieve MCLs is based on decay rates that are not adequately supported by the data and by excluding wells that have stable, indeterminate, or increasing trends. The Tech Memo provides no quantitative time to achieve MCLs for the Lower Aquifer (regional water supply aquifer) and provides no support for the conclusion that the time to achieve MCLs in the Lower Aquifer will be the same as the Upper Aquifer. Based on the Focused FS, the time to achieve MCLs in the Lower Aquifer will be over twice as long as the time to achieve MCLs in the Upper Aquifer. Therefore, the Water Board finds that the Focused FS still provides the most realistic cleanup timeframes for CG070.

Comment 15: Section 5.1.1.2, Plume Stability or Reduction Over Time

This section references figures 4-1 and 4-2 as supporting evidence that the plume size is decreasing over time. The figures that show the interpreted extent of the plume above the MCL for different time periods are actually figures 3-2 and 3-3. Figures 4-1

and 4-2 show the interpreted extent of the plume in 2013. Figures 3-2, and 3-3 do not adequately support the conclusion of plume stability for the following reasons:

a. The figures 3-2 and 3-3 do not show the data points or include the procedures used to contour the data. Also see Comment Enclosure 1, Comment 28.

b. The changes in plume configuration are at least partially the function of changes in the monitoring network. As additional wells have been added to the monitoring network, the plume configuration has been refined. Additionally, many of the high concentration wells have not been sampled since 2004 (see Comment 15.c).

c. Some of the changes portrayed in these figures appear to be the result of how the isoconcentrations contours were constructed. For example, after 2012, isoconcentrations contours for the Lower Aquifer were drawn in a manner that creates three separate plumes rather than one large plume with three hot spots. This change appears to be largely the result of changes in how the data was contoured, not an actual change in the size of the plume. Also see 14.e and Enclosure 1, Comment 28.

d. The Lower Aquifer plumes are not well defined, e.g. there are no wells downgradient of hot spot well, NZ-84, and only one well downgradient from hot spot well, EW-6. Additionally, recent increases at downgradient wells, NZ-98 and NZ-72 may indicate plume migration to the north (note, the detection of 7.8 in NZ-98 is shown on Figure 4-2, but this point was not honored in the construction of the 5 µg/L isoconcentration contour). Finally, there are no wells located directly between the areas of contamination in the Lower Aquifer; therefore, it is not clear if these areas represent separate plumes or one larger plume.

e. The figures are confusing because they don't distinguish between the CG070 plumes and plumes associated with the flightline area.

f. The figures do not include an isoconcentration contour for less than the MCL. Therefore, the entire areas of impacts are not shown. Please revise to include all data.

Comment 16: Section 5.1.1.3, Projection of Future Upper Aquifer Concentrations

The Water Board does not accept the Tech Memo's analysis of half-lives/attenuation rates that are the basis for the projections of the time to reach the MCL (see Comment 15 and Enclosure 1). The Tech Memo appears to exclude wells with indeterminate, stable, or increasing trends for its evaluation of time to reach MCLs. The longest time to reach MCLs, i.e., 80 years, is based on the Tech Memo's calculated decay rate for NZ-93. However, the correlation coefficient calculated for the TCE trend for NZ-93 was 0.07. A correlation coefficient of 1 indicates a perfect fit between the data and the trendline and a correlation of 0 indicates there is no correlation. Therefore, there is essentially no correlation between TCE data at NZ-93 and exponential decay (USEPA Rate Constants Guidance states that a correlation coefficient of at least 0.9 is necessary for quantitative use). The trend plots in Attachment 3 of the Tech Memo do not show a regression analysis for NZ-93, but based on visual examination, TCE concentrations increased from non-detect in the first sampled event in 2001 to a

maximum of 85 µg/L in 2007 and have fluctuated between 40 and 70 µg/L since 2008. These trends are not consistent with exponential decay. Therefore, the Tech Memo does not provide a valid evaluation of the maximum time to achieve MCLs in the Upper Aquifer.

Finally, the Focused FS predicted continued migration of the TCE plume in the Upper Aquifer, i.e., the 5 µg/L isoconcentration contour will migrate 1,500 feet to the northeast. Additionally, TCE from the Upper Aquifer plume continues to migrate vertical into the PLZ and the Lower Aquifer. The Tech Memo does not provide an adequate basis for discounting the Focused FS's prediction of continued plume migration.

Comment 17: Section 5.1.1.4 Lower Aquifer ND Projections

The Water Board does not accept the Tech Memo's evaluation of the Lower Aquifer plume behavior or the assumption that it will take the same time for the Lower Aquifer plume to reach MCLs as the Upper Aquifer plume (see comments 13-15). Modeling reported in the Focused FS showed it will take over twice as long to reach MCLs in the Lower Aquifer than the Upper Aquifer. Decreases in TCE concentrations on the east side of the Lower Aquifer plume noted in this section are the result of the change in groundwater flow direction caused by the mound associated with the VVWRA infiltration ponds. The current monitoring well network is inadequate to evaluate the extent or the migration of TCE in the Lower Aquifer (see Comment 15.d).

Additionally, the Focused FS contained a figure that showed a decreasing TCE mass trend in the Upper Aquifer and an increasing TCE mass trend in the Lower Aquifer. Continued mass transfer from the Upper Aquifer and MLZ/PLZ into the Lower Aquifer and the lack of destructive attenuation processes makes it unlikely that the Lower Aquifer plume is currently stable or will remain stable. The three Lower Aquifer hotspot wells, EW-6, NZ-84, and NZ-107, show increasing trends since GETS shutdown in March 2003. NZ-107 appears to have been stable since 2008, but NZ-80, the well downgradient of NZ-107 is still increasing. Additionally, there have been recent spikes in TCE concentrations at NZ-98 and NZ-72. NZ-98 is downgradient of hot spot well EW-6. NZ-72 is over 2,000 feet from EW-6 plume. NZ-72 has been non-detect since 2000 but, in 2014, TCE was detected at 7.6 µg/L. It is unclear if the detect above the MCL in NZ-72 represents lateral plume migration or vertical migration from the Upper Aquifer and/or MLZ/PLZ along a new vertical pathway. Also, many of the Lower Aquifer wells have experienced a significant rise in water levels from infiltration from the VVWRA ponds. The water level rise may decrease TCE concentrations in the monitoring well, which may be masking increasing TCE trends in the plume.

Finally, the Focused FS predicted continued migration of the TCE in the Lower Aquifer plumes, specifically, the 5 µg/L isoconcentration contour will migrate 2,000 feet to the north and 3,000 feet to the southwest. The Tech Memo evaluation is not adequate to supersede the Focused FS predictions.

Comment 18: Section 5.1.2 Observed Decreases in Plumewide Averages

Water Board staff does not concur with the evaluation of the plumewide average used in this section (see Enclosure 1, Comment 26).

Comment 19: Section 5.1.3 Tier 2 – Hydrogeologic and Geochemical Data.

This section includes a discussion of data from at least two monitoring wells that are outside of the CG070 plumes. The evaluation of hydrogeologic and geochemical data should be restricted to CG070 wells (see Comment 14.d).

Comment 20: Section 5.1.3.2 TCE/Chloride Ratios

This discussion includes several unsupported assumptions that Water Board staff does not accept, specifically:

a. Staff does not concur with the assumption that there is no significant infiltration of precipitation. See Enclosure 1, Comment 6.

b. Staff does not concur with the assumption that the GETS treatment system did not alter the chloride concentrations. The discharge of the treated water to the infiltration ponds would result in evaporation. Additionally, discharge to the old sewage ponds would mobilize salts in the vadose zone in the same manner nitrate was mobilized (see Comment 11.b). All of these processes would change the chloride content.

c. Staff does not concur with the assumption that the chloride concentrations of water supply sourced from groundwater would not be changed by use, wastewater treatment, or discharge to infiltration ponds. All those processes would alter the chloride content of the water.

Therefore, Water Board does not concur with the conclusions based on these assumptions.

Comment 21. Section 5.1.4.1 Maximum Plume Concentration

This section states that Figure 3-4 shows a declining TCE trend based on the maximum TCE detected in each sampling event. However, this type of evaluation will be affected by the selection of wells sampled and the operation of the GETS. For example, it appears that many of the high concentration wells, e.g., NZ-40, NZ-55, NZ-82, and NZ-83, have not been sampled since 2004. Therefore, the plot of mass will be skewed by the lack of recent samples in these high concentration wells.

Comment 22. Section 5.1.4.2 Plume Mass Loss Over Time

This evaluation is based on figures 3-2, 3-3, and 3-4. Because Water Board staff does not concur with the construction or use of these figures (see comments 15 and 21), staff does not concur with the conclusions of this section. Additionally, staff does not concur with the statement that maximum concentrations in the Lower Aquifer have declined since 2009 or with the conclusion that the Upper Aquifer and PLZ are no longer acting as sources to the Lower Aquifer (see comment 13.b, 16, and 17). The last conclusion is also inconsistent with Focused FS which concluded that those zones would continue to act as sources for the Lower Zone so that MCLs would not be reached for 500 years.

Comment 23. Section 5.2 Uncertainty Assessment

The uncertainty analysis is incomplete. Examples of additional uncertainties include the following:

a. Remaining sources in the unsaturated zone.
b. Contaminant mass in the MLZ/PLZ.
c. Migration pathways from the upper to lower aquifers.
d. Mechanisms and future occurrences of pulse-type migration of TCE to groundwater.
e. Changes in groundwater levels and groundwater flow direction that could cause additional TCE mass entering groundwater or plume migration.
f. Future need for the groundwater.
g. Reliability of ICs and monitoring network over long cleanup period.
h. Decay rates.
i. Uncertainties associated with long cleanup timeframe.
j. Travel time to exposure points

Additionally, staff does not concur with statement that the Tech Memo uses conservative estimates to calculate time to achieve MCLs. See comments 13 - 22 and Enclosure 1.

Comment 24. Section 6.0 Discussion of MNA Appropriateness

The first page of this section states that Site CG070 meets the EPA MNA Directive's two criteria for MNA, i.e., source control or implementation of MNA following active remediation. However, these are two basic conditions that the Directive states where MNA will "be most appropriate" and not actual criteria for MNA selection. This section references Table 6-1 for a discussion of additional Directive conditions to be considered. The discussion in the table states that all of these conditions have been met at CG070. However, Water Board staff does not agree with this conclusion. The following is a list of the conditions and staff response to the Tech Memo's determination in Table 6-1 that the specific condition has been met.

a. *Whether the contaminants present in soil or groundwater can be effectively remediated by natural attenuation processes.* See comments 13-18 and 21-23.
b. *Whether or not the contaminant plume is stable and the potential for the environmental conditions that influence plume stability to change over time*; See Comments 11, 13-17, and 22.
c. *Whether human health, drinking water supplies, other groundwaters, surface waters, ecosystems, sediments, air, or other environmental resources could be adversely impacted as a consequence of selecting MNA as the remediation option*; See Comment 8, 11.e,
d. *Current and projected demand for the affected resource over the time period that the remedy will remain in effect.* Because of the 500 year timeframe to achieve MCLs, it is not realistic to assume the groundwater resources will not be needed during this time period.
e. *Whether the contamination, either by itself or as an accumulation with other nearby sources (on-site or off-site), will exert a long-term detrimental impact on available water supplies or other environmental resources.* See comment 12 and 26.

f. *Whether the estimated timeframe of remediation is reasonable compared to timeframes required for other more active methods (including the anticipated effectiveness of various remedial approaches on different portions of the contaminated soil and/or groundwater).* See Comments 14, 16, and 17.
g. *The nature and distribution of sources of contamination and whether these sources have been, or can be, adequately controlled.* See comments 4 and 13 and Enclosure 1.
h. *Whether the resulting transformation products present a greater risk, due to increased toxicity and/or mobility, than do the parent contaminants.* Water Board staff agrees that, under current conditions, no significant transformation products are being produced at Site CG070. However, because of the 500-year timeframe to achieve MCLs, these conditions could change in the future.
i. *The impact of existing and proposed active remediation measures upon the MNA component of the remedy, or the impact of remediation measures or other operations/activities (e.g., pumping wells) in close proximity to the site.* Staff does not agree with the Air Force evaluation of the GETS. See Comments 2 and 11.b.
j. *Whether reliable site-specific mechanisms for implementing institutional controls (e.g., zoning ordinances) are available, and if an institution responsible for their monitoring and enforcement can be identified.* See Comment 12.

Additionally, this section does not address the USEPA MNA Directive's statement regarding reliance on natural attenuation processes:

> When relying on natural attenuation processes for site remediation, EPA prefers those processes that degrade or destroy contaminants. Also, EPA generally expects that MNA will only be appropriate for sites that have a low potential for contaminant migration.

Destructive processes are not occurring at CG070 and because of the uncertainities and long cleanup timeframe, the Air Force cannot adequately demonstrate that there is low potential for contaminant migration.

This section also refers to the application of MNA as a "polishing" step at this site. However, based on the size of the plumes (the areal extent of the Upper Aquifer plume is in excess of the MCL is 680 acres) and the estimated time to achieve MCLs using MNA (i.e., 500 years), Water Board staff does not view MNA at CG070 as a polishing step and does not agree that no additional active remediation is necessary. Although active remediation in the form GETS was implemented, it was terminated because of problems with the overall remedy with the intent of gathering additional data in order to optimize the system. The optimization effort was not completed. Therefore, based on the unreasonable timeframe to achieve MCLs using MNA, the Water Board finds that additional active remediation is necessary.

Finally, during the September 2014 Water Board meeting, Board members indicated that site conditions that would require more evaluation and deliberation by the Board and which may preclude the selection of MNA included the following.

a. *Groundwater contamination impacts a primary water supply aquifer for an adjacent community or we anticipating needing the water resource in the future.* CG070 does impact a primary water supply aquifer for the adjacent community.

b. *Site is proximal to a population center or in an area that is likely to be developed in the future.* CG070 is within the City of Victorville and adjacent to residential and commercial areas.

c. *The plume extends beyond the responsible party's property.* Over half of the lateral extent of the Upper Aquifer is off site (beyond former GAFB boundaries) and the Air Force intends to sell the remaining onsite portion in the near future.

d. *Land use restrictions will impact non-responsible parties.* ICs will impact non-responsible parties. See Comment 12.

Therefore, all the Board member concerns regarding the application of MNA apply to CG070, and it appears unlikely that the Water Board would accept MNA.

Comment 25. Section 6.1 Reasonable Timeframe

Water Board staff does not concur with the Air Force's conclusion that the timeframe to achieve MCLs under MNA is reasonable. Firstly, staff does not concur that the Tech Memo establishes that MNA will take less than the 500 to reach MCLs as estimated in the Focused FS (see prior comments). Secondly, the Tech Memo misrepresents statements by Water Board members during the September 2014 Meeting. At the meeting, Board members stated that the cleanup timeframe must be considered on a case by case basis, i.e., 10 years may be reasonable at most sites, 40 years may be appropriate at some sites, 100 or more years may be acceptable in a small number of cases, e.g., an isolated, active military base. However, any MNA timeframe of 100 or more years will receive an intensive review by the Board members. Additional factors that the Board members indicated that would need to be considered for acceptance of MNA remedy with a longtime frame for cleanup included the following.

a. *The potential benefits of active remediation to achieve cleanup goals in a shorter timeframe and decrease the extent of impact.* Active remediation would shrink the plume and achieve cleanup goals faster than MNA.

b. *The responsible party's ability to control the site and the area around the site, e.g., plume is contained within an active military base.* See Comment 12.

c. *Strength of triggers and contingencies. Triggers should:*

   - *Include achieving milestones during the cleanup process.*
   - *Address changes in assumptions used for MNA selection.*

   Triggers and contingencies remain an uncertainty at CG070.

d. *Strength and confidence in institutional controls.* Water Board staff has determined that the proposed ICs are not adequately protective. See Comment 12.

e. *Financial assurance in place to maintain the MNA remedy.* It is difficult to confidently project funding for 500-year period.

f. *The burden on Water Board resources to oversee long-term cleanup.* The burden on Water Board resources would be ongoing for a very long time and there would be no cost-reimbursement for oversight of ICs.

Based on these conditions, it is unlikely that MNA as a sole remedy will meet Water Board requirements.

Comment 26. Section 6.2 Appropriateness

This section provides a discussion of headings included as the USEPA MNA Directive's balancing factors when determining whether a particular timeframe is appropriate and reasonable.

a. *Classification of the affected resources and value of the resources.* This section should be revised to note that the Lower Aquifer is a drinking water supply aquifer (not just a potential water supply). Also, the section only acknowledges water supply wells of the cities of Adelanto and Victorville. The evaluation of drinking water receptors should include the potable water supply wells are the VVWRA, which are directly downgradient of the Lower Aquifer plume, the Bureau of Prison Wells south of CG070, and the water supply wells in the Flood Plain Aquifer (see Comment 8). This section should also be revised to acknowledge the surface water receptors discussed in the Focused FS.

b. *Relative timeframe in which the affected portions of the aquifer might be needed for future water supply.* Water Board staff does not concur with the statements that "it is unlikely that the environmental conditions that influence plume stability will change over time" or that "there are no current plans to cease operation" of the VVWRA ponds. VVWRA recently informed Water Board staff that when funding becomes available the plant will be upgrade to meet recycled water requirements and discharge to the infiltration ponds will decrease and ultimately cease. When the groundwater mound created by pond infiltration dissipates, plume migration will likely revert to the northeast, threatening the Flood Plain Aquifer and water supply wells.

c. *Whether the contamination, either by itself or as an accumulation with other nearby sources, will exert a long-term detrimental impact on available water supplies or other environmental resources.* Staff does not concur with the statements that there is little impact to existing water rights or local agency plans and the TCE plumes do not impact environmental resources. Over half of the lateral extent of the Upper Aquifer is off site (beyond GAFB boundaries) and the Air Force intends to sell the onsite portion in the near future. The Air Force is proposing ICs to prohibit of the use of groundwater beneath onsite and offsite properties (see comment regarding ICs). The prohibition of the use of the underlying groundwater represents a significant restriction of property rights. The Air Force's proposed ICs would put the burden of restricting the groundwater use on San Bernardino County and the City of Victorville (see Comment 12). Additionally, the plume is currently impacting and will continue to impact both the beneficial uses of the Upper Aquifer and Lower Aquifer and threatens the beneficial uses of the Flood Plain Aquifer and the Mojave River. Finally, the

areal extent of the Upper Aquifer plume is approximately 680 acres. The vertical extent of TCE includes the thickness of the Upper Aquifer and extends into the Lower Aquifer. Therefore, the volume of water that does not currently meet benefical use standards is very significant. The impacted water should be restored to its beneficial use as soon as technical feasible, especially in light of future needs and current drought conditions.

d. *Uncertainties regarding the mass of contaminants in the subsurface and predictive analyses (e.g., remediation timeframe, timing of future demand, and travel time for contaminants to reach points of exposure appropriate for the site).* This section does not adequately address the uncertainties associated with MNA at this site (See Comment 23). Additionally, Water Board staff does not accept the estimates of time to achieve MCLs presented in the Tech Memo. Therefore, the estimated timeframe to achieve MCLs under the MNA remedy is as presented in the Focused FS, i.e., 500 years. Staff also does not accept the statement that the "plume is shrinking" (see comment 13, 15, 16, and 17).

e. *Reliability of monitoring and of institution controls over long periods.* Staff does not agree that long-term monitoring and maintenance of ICs for hundreds of years is well understood and an accepted practice (see Comment 12).

f. *Provisions by the responsible party for adequate funding of monitoring and performance evaluation over the time period required for remediation.* It is difficult to predict long-term funding for the 500 year cleanup timeframe to reach MCLs.

Comment 27. Section 7.0 Conclusions

Based on the preceding comments and Enclosure 1, Water Board staff disagrees with the conclusions that MNA is appropriate at this site, the existing monitoring network is adequate, attenuation is adequately protective, the plumes in both aquifers are stable, and that the timeframe for remediation using MNA is reasonable.

Comment 28. Section 7.0 Conclusions

The analysis under the heading "Where is TCE Going" is not a conclusion and should have been provided in the body of the text or an attachment. Comments on the analysis under this heading are provided in Enclosure 2.

Comment 29. Section 8 References

This section does not reference the regulatory-accepted version of the document, i.e., Final Focused FS, Revision 4, dated August 9, 2012. The document should be revised to reference the regulatory-accepted version of the document and to ensure all referenced material from the Focused FS are consistent with that version.

Comment 30. Regarding Compliance with State Plans and Policies

State Water Resources Control Board Resolution 92-49 requires that dischargers clean up affected groundwater to background water quality or the best water quality that is reasonable considering the factors listed in the resolution and that does not exceed

water quality goals. The Air Force has not adequately demonstrated that the proposed remedy will meet the requirements of Resolution 92-49, which must be satisfied prior to Water Board's acceptance of any cleanup level above background. Generally stated, these requirements are:

- Be consistent with maximum benefit to the people of the state;
- Not unreasonably affect present and anticipated beneficial use of such water;
- Not result in water quality less than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards.

The *Water Quality Control Plan for the Lahontan Water Region* (Basin Plan) specifies the beneficial uses of the Mojave Basin groundwater include municipal and domestic water supplies. Under the Air Force's proposed remedy, groundwater will continue to exceed a drinking water standard for 500 years. Therefore, the proposed remedy will not meet the Resolution 92-49 requirements 2 and 3 for 500 years. Water Board staff finds that a 500-year timeframe to meet the listed requirements is not reasonable and that the Air Force has not adequately demonstrated that the MCL is the best water quality that is reasonable per Resolution 92-49.

Thank you for the opportunity to review the Tech Memo before issuance of the ROD Amendment. Staff looks forward to working with the Air Force to reach resolution of the issues expressed in this letter. You may contact Linda Stone at (530) 542-5471, Linda.Stone@waterboards.ca.gov, or Cindi Mitton (760) 241-7413 Cindi.Mitton@waterboards.ca.gov, if you have any questions regarding this letter.

Linda Stone PG, CHg
Engineering Geologist

Enclosures:
1. Memorandum from Alice Campbell, DTSC, dated June 10, 2015
2. Additional comments from Alice Campbell, DTSC, email dated July 20, 2015

Ccs: Steve Ashton, City of Victorville, Public Works
Mary Aycock, USEPA, Region IX
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LS/dk/T: GAFB OU1 CG070 MNA TM LS CM com
GT/DOD/GAFB

Enclosure 1

Department of Toxic Substances Control

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MEMORANDUM

TO: Ms Linda Stone, PG, CHg
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FROM: Alice Campbell, PG, CEG, CHg
Senior Engineering Geologist
Chatsworth Geological Services Unit

CONCUR: Craig Christmann, P.G.
Senior Engineering Geologist
Chatsworth Geological Services Unit

DATE: June 10, 2015

SUBJECT: Review of May, 2015, Draft Technical Memorandum, Evidence for Natural Attenuation, Site CG070,OU1, by CB&I Federal Services LLC, for Former George Air Force Base, Victorville, California.

RWQCB PCA: 16661 DTSC PCA: 14718 Site Code: 400071-47 WRNo.20025728

Introduction:

At your request, the Chatsworth Geological Services Unit (GSU) prepared this memorandum to provide comments on the above-referenced Technical Memorandum submitted to the RWQCB for this facility. The former George AFB has a number of OUs. Site CG0703 consists of a low-concentration TCE plume in the Upper and Lower aquifers in the northeastern part of AFB George. The plume trends north and northeast.

The site also has a historical nitrate plume associated with the sewage treatment plant percolation ponds, but the nitrate plume is not a part of this study. The RAOs for the site are to prevent exposure under an unrestricted use scenario, and to reduce concentrations to a level that will be protective of groundwater. There is concern about the length of time the existing plume will be detectable, since it is heading towards VVWRA production wells in a lower aquifer.

A groundwater pump-and-treat system began in 1991 as an interim remedial action. It consisted of 9 extraction wells and a treatment plant, and percolation ponds to dispose of treated water. Some water was also sent to an unnamed arroyo. Six extraction wells were in the upper zone and three were in the Lower Aquifer. Water was apparently treated to the MCL of 5 ug/L TCE. A second treatment phase started in 1996 with 9 new wells.

The system was shut down in March 2003 when TCE concentration in the lower aquifer started to increase. Remediation shifted to SVE in source areas near the flightline and other areas. SVE extraction started in about 2007 and continued until 2012-present depending on factors such as rebound testing or air emissions problems. Both TPH and solvents were recovered by the SVE systems.

General Comments

1. Section 2 Background. Figure 2-2 or a similar figure needs to show the locations of the extraction wells, Site WP026 STP percolation ponds, the new percolation ponds, and the location of the 'unnamed arroyo'.

2. Section 3.1 Conceptual Site Model. The CSM summary is too general to explain features observed on the time series charts, and does not include recharge from rainfall, the effects of mounding, and the interaction of fuels and solvents in sorption and dissolution.

3. Figure 3.1 The cartoon of the CSM leaves out many relevant details found in the earlier 2011 Focused Feasibility Study. In particular, the Lower Lacustrine unit is not flat, but is dips downward to the south. The shape of this zone is important in downward migration of contaminants. Attached is a cross section (Figure 1) showing groundwater streamlines and TCE concentrations along a line between the Fire Training area and the Victor Valley water treatment plant. Streamlines show an initial northward trend, but also a southward tend in the Lower Lacustrine unit. Where the perched zone ends, contamination is seen in the Lower Aquifer. Attenuation across the vadose zone is not great, because concentrations at Lower Aquifer well NZ-37 are only an order of magnitude

smaller than in the Upper Aquifer. NZ-135 shows the effects of downward gradients induced by pumpage from the deep aquifers tapped by the water supply wells. Cross sections along the axis of the plume are useful in both showing actual conditions, and in justifying the proposed attenuation mechanism.

4. Section 3.2 The discussion should include descriptions of how the contamination occurred and spread, and tie it back to the CSM. For example, for SD025, explain how the contamination vanished from the soil. Was it by infiltration of subsequent stormwater? Did stormwater carrying solvents discharge to the unnamed channel? The 2011 Focused Feasibility Study showed the entire stream channel as a source area.

5. Please include a figure showing the declining nitrate trend from OU WP026, along with water levels, and indicate when the pond was in use and when use stopped.

6. Section 3.3, TCE Concentrations vs Conceptual site model. The CSM has many unstated assumptions and is not entirely consistent with observed trends in the time series charts. The time series charts show pulses of contamination, not steady-state sources, indicating that the initiating events are short-term. In some cases this can be tied to infiltration ponds located near source areas, but not in all cases. While downward percolation of water is one mechanism for moving contamination into groundwater, there is another mechanism that has not been identified. Attached is a figure (Figure 2) showing Well FT-05 in the FT019 area. Superimposed are water levels and the well log for the well. It shows that the groundwater surface rose into a source zone, and the TCE release occurred immediately, and declined with the water levels until recently, when a small pulse occurred. The following figure (Figure 3) shows rainfall superimposed, and it suggests that infiltration of rainfall through source zones also moves pulses of contaminants independent of water levels. The recent increase in TCE concentration was not a result of rising water levels. These mechanisms need to be described in this section.

7. Based on the above observations, it appears that the declines in concentration are not related to the pump-and-treat remedy; the declines are a result of removing the sources of infiltration that raised water levels into source zones. The concentrations fell when the sources drained to below field capacity. Pulses are still being generated locally, and groundwater flow directions have shifted because of changing areas of infiltration such as the construction of the Victor Valley wastewater treatment ponds overlying the eastern part of the lower unit. Note that the ponds do not affect the perched Upper Aquifer. The idea of plume stability rests on an unspoken assumption that source zones will never

resaturate. The mechanism preventing resaturation should be described. The conclusion that the plumes are 'stable' is incomplete, the plumes will recur if the source resaturates unless the sources are removed or immobilized.

8. Section 3.4. The discussion of the attenuation mechanism would benefit by preparing a pulse model similar to GSUs (see Figure 4). The fit required attenuation by retardation, and would not fit without it. The pulse fit required a velocity of 0.08 ft/day, retardation, no decay, and minimal dispersion. The section should be revised based on a better mechanism and model fitting. Note that the hydraulics of the plume involve moving water across the Lacustrine Unit to the Lower Aquifer. From the point of view of the lower aquifer, this would behave like a leaky aquifer, where the flow from leakance would add to the flow in the Lower Aquifer. Using a conductivity different of 10%, the Lower Aquifer concentrations would look like a 10% attenuation, which is consistent with observed concentrations and with Figure 3-1. The EPA model is for a homogenous, isotropic aquifer. The system at George is considerably more complex, but is still tractable. The attenuation model should be revised. Note that Figure 3-1 implies a steady-state, attenuating plume, but in reality the upper aquifer generated a saturation pulse that is now in a slow drip phase.

9. Section 3.4 The statement that the Mojave River is a groundwater divide is inaccurate. Rivers can form constant-head *boundaries* if (and only if) they transect the entire aquifer. A river only slightly entrenched does not fit the definition. The membrane effect at the base of the channel limits downward flow. When pumpage exceeds downward flow, the river dries up and groundwater to the west of the river will move east. Because the river is not deeply entrenched, groundwater in layered sediments 100 feet beneath the riverbed are not necessarily even directly linked to the river. Models need to explicitly show the channel bottom conductivity and the extent of recharge to layers beneath. It is very easy to put a constant head boundary into a model, but actual constant head boundaries are rare. The Los Angeles River is an example of a river not in communication with deep aquifers and is not an impediment to pumping-induced movement of contaminants. No evidence has been presented showing showing how pumpage of the FPA would affect flow. The proposed Shay Road fault is shown as not being a flow barrier. The sentence should be removed.

10. Last sentence. The conceptual model would be better revised now than waiting another five years.

11. Attachment 1. General comment about time series charts. All the charts need integral titles with the name of the well. The time series charts have numerous formatting and data problems, too many to list individually. The data values for

TCE are not joined by lines. This leads to the perception that the data are have a lot of variability and obscures recognition of pulses of contaminants and the shape of the ascending and descending limb of the pulses. The shape of the limbs can be diagnostic of the type of pulse. Some charts have logarithmic concentration axes, which also obscures trends. The groundwater elevation axes are forced to a narrow band in order to show the screened interval, which has no obvious effect on either water levels or TCE concentrations and is better left off. Both vertical axes should be allowed to be fit automatically. When GSU reformatted the charts, we discovered that in some cases, the axes had hidden relevant data, including a few cases where increasing trends were hidden by the timescale or vertical axes. Finally, ND data was mixed in with detects with no way to distinguish them, which makes trends in the actual data impossible to figure out. The exponential fits were done to a selected part of the data without any explanation of how the data were selected. Sometimes one pulse was selected, sometimes two or more were used (see Figure 5). The fit selection needs to be documented, and preferably be consistent. The exponential fit model is obviously not very good, particularly if the data series are shown with lines connecting the dots. The numerical fit quality is similar to the visual fits- not very high confidence. Finally, the line indicating the GETS Shutdown appears intended to link the decline in TCE with the shutdown. A line at the other side, when the GETS started up, would show that the startup coincided with the rise in concentration at many wells in the central area. If the GETS shutdown is shown, then the startup should also be shown.

12. Section 4.2.4. The argument that trends are stable or declining would be stronger if all the data was actually being used in the analysis. One missing dataset appears to be water levels from before 1993, which are missing on the plots. Normally, water levels are measured when the well is sampled, and TCE measurements show the wells were sampled, but there are no water levels for the sampling event. Early water levels are needed in order to understand early TCE pulses. For example, LW-2 had a pulse in 1993 before the GETS started. Without water levels, it is hard to determine why the pulse occurred. If rainfall is layered on the plot, there are two large rainfall events that could have mobilized TCE, but similar rainfall events did not. The pulse might have been related to earlier locations of water treatment ponds, but it cannot be figured out without water level data. Oddly, Figures 4-1 and 4-2 show some of the older data, but the Attachment 1 figures do not.

13. Figure 4-1, 4-2. The charts show concentrations on a log scale, which visually flattens trends, and compresses the water levels. A two-order of magnitude spike is harder to see than it would be on a linear scale. The charts should have linear concentration axes so that actual concentrations are apparent.

Furthermore, the time axis limits should be identical so that charts can be compared. One way to track plume decay rates is to line up time series along a flowline and note the change in the ratio of height to width of the TCE curve. This rate of change can be modeled using a pulse decay model and the decay rate and plume velocity calculated. The figures should be revised.

14. Section 2.2.4 Well NZ-129b shows two distinct pulses, echoed by NZ-129c at about 10% of the concentration of the shallower well (see Figure 6). This demonstrates downward migration, not horizontal flow towards the river. Wells 130a and 130b show the same pulse at the same time. The narrow pulses are not the remains of a decaying pulse that has moved a long distance, because it happens too fast. This pulse originated somewhere very close to the wells. Both TCE pulses happened just after water level peaked, fell, and peaked again, suggesting a link between the water levels and TCE concentrations. The pulses are similar to what happened at the fire training area, which seemed linked to saturation of contamination near the water table by a rise in the water table. This in turn suggests that source removal would prevent future contaminant releases to groundwater.

15. Section 2.4.6 The monitoring program, particularly the time series, show how strongly TCE contamination is linked to rises in water levels and infiltration of surface water. The current drought has reduced the frequency of rainfall recharge events, but there is no mechanism in place preventing resaturation of source zones. Such a mechanism would need to address both ponding and rises in the water table. The document does not address this because the document does not acknowledge the role of surface infiltration in generating the contaminant plume. There is no reason to expect that future saturation events will fail to generate new plumes. The best way to prevent new pulses from being generated is to remove source material.

16. Section 4.2.7 Institutional controls do not include prohibition of percolating large volumes of water at the surface anywhere near source areas irrigated agriculture or large decorative plantings, lining the surface water drainages to prevent infiltration, prohibition on percolating roof runoff as recharge on buildings, prohibition of septic systems, and positive drainage in known source areas. The site conceptual model needs to be changed to accurately describe the sequence of events leading to the discharges so that the correct institutional controls can be established.

17. Section 5.1.1 Groundwater concentration trends with time. The document does not describe the actual trends, which consist of one or more individual pulses of contamination in response to specific wetting events. Superficially, the declining

limb of a pulse decay looks like exponential decay if the rising limb is ignored. The mathematics is different, however. The poor exponential fits demonstrate that the decay model being used is inappropriate.

18. Some of the trends were obscured by the scales of some of the charts in Attachment 1. At NZ-130a, an exponential curve was fit to one of two pulses for no apparent reason. There is no obvious reason from the chart that there will never be another pulse generated. In setting axes for charts, some data was hidden that indicated rising trends.

19. Section 5.1.1.1. GSU disagrees that the exponential fits forced onto the data correctly describe the actual data on the charts. The charts show obvious sequences of pulses each with its own decay limb. Since the same pulses were not fit in every case, and in some cases more than one pulse was included, there is no such thing as average decay rates. There is no reason to believe that additional pulses will not occur. The pulses are generated by specific circumstances and these circumstances have not been positively prevented going forward. The pulses have decayed because the ponds have been moved, and because of a major drought. The source material near the water table has not been removed, so the contaminants are simply hibernating.

20. GSU disagrees with the time of compliance because of the inconsistent way the pulses were analyzed, and because the wrong model was used. GSU does not disagree that TCE concentrations are declining; GSU disagrees that the decline is permanent. The conclusion that the duration in the lower aquifer would be comparable to the duration in the upper aquifer cannot be true, because pulse peaks decline and durations increase with distance traveled. This is part of the physics of groundwater flow and transport. The duration in the Lower Aquifer will be proportional to groundwater velocity, initial concentration, the time of travel, retardation, and lateral and vertical dispersion. It will almost certainly be longer than in the upper zone.

21. The Lower Aquifer gets its water from the Upper Aquifer after a delay determined by the distance water moves from the source to the well. Visual inspection of the charts show that many pulses in the Lower Aquifer rise more slowly and decline more slowly, which is characteristic of a decaying plume at a distance from the source. Pulses still in transit will probably continue to show up at the deeper wells.

22. Section 5.1.3, Figure 5-9. DO data is obviously problematic; DO values greater than solubility limit are being reported. DO is also greater than 1 at negative ORP. The lack of positive correlation between ORP and DO indicates the DO

sensor is malfunctioning. DO meters use a semipermeable membrane with a finite lifetime, and there is no warning or calibration in the machine when the membrane no longer functions. The user needs to QA the data and when the DO data no longer correlates to ORP, the membrane needs to be replaced.

23. Conclusions based on DO data should be reviewed and ORP used instead. GSU agrees that TCE biodegradation is small and localized, and should not be considered a primary attenuation mechanism.

24. Figure 5-9. Note that TCE is at parts per billion, but DO is at parts per million. ORP values range from -300mv to +300mv or so. It's not clear that TCE could actually have any direct effect on either of the two parameters.

25. Attachment 2a, 2b. The idea behind the exponential fits is that the source mass is declining. Exponential decay is properly used for the actual decay of the source over time. Radioactive decay is an example. Use of an exponential model implies that the source mass has declined. However, the time series show a series of pulses, not a gradual decay. The actual release mechanism does not fit the exponential model being used. This issue is never explained in the site conceptual model. The attenuation rates need to be revised and a appropriate model used.

26. Attachment 4. Average Plume Values. The 'average' plume values were calculated by again assuming a monotonic decay of a source and plotting 3-year groupings of wells, averaging the data, and invoking an average decline. The problem is that the hydrographs show pulses, and the time slices could also be chosen in a way to show concentrations are increasing. In a water-driven system, lack of water would also produce what looks like a decline, but is actually a gradual drying up of the transport system. This kind of analysis is easy to manipulate to show any desired outcome. As discussed in the first comment, the hydrographs show that rainfall can also drive pulses because there is still source material in the vadose zone. The recent drought has reduced the frequency of saturation events, but the potential remains for a wet winter to generate new pulses of TCE. This is inconsistent with the analysis in Attachment 4. An attached figure illustrates fitting data to a pulse model, which has a residual error of less than 1 %. Excel's curve fitting module can handle polynomial fits, so all that is needed is to change from a plain exponential to a pulse decay fit.

27. Earlier JMM reports acknowledged the role of the GETS and the water treatment ponds in causing TCE concentrations to increase and the plume to spread. The conceptual model was never updated to include wetting of source material close

to the water table, and the source material within reach of the water table was never removed or treated. The conceptual model needs to be updated.

28. There is little consistency or rigor in contouring groundwater, delineating plumes, or fitting trends to the data. This reduces confidence in the figures, and makes the results more an opinion and less of a technical result. GSU has asked that the groundwater be contoured using TIN, which produces repeatable and consistent contour maps. GSU has advocated drawing flow lines over the contours and using the flow lines to outline plumes. This method produces highly consistent plume maps that honor the data and are repeatable for the same dataset.

29. Current SVE systems and the proposed ozone pilot study are in areas where there is documented TCE near the water table. TCE in substantial amounts near the water table needs to be a priority target for remediation because of the difficulty of preventing rises in the water table during wet El Niño years. GSU has previously requested that source areas, particularly in the Fire Training area, be graded to prevent ponding of rainfall.

Conclusions and Recommendations:

1. GSU disagrees with the use of exponential curves to calculate attenuation rates. In particular, GSU believes that a pulse model more accurately describes the observed trends.

2. GSU objects to the manipulations of the data in Attachment 2. The attenuation calculations based on poorly chosen fits or hidden data need to be redone, and the charts reformatted.

3. GSU requests that the attenuation calculations be redone using a pulse model.

4. GSU recommends more source removal to prevent recontamination events.

5. GSU recommends institutional controls to prevent infiltration and percolation of water in known source areas and in the plume areas to prevent further spreading. While offsite changes in water extraction and disposal cannot be controlled, the neighboring water handlers, both extraction and disposal, need to be aware that major changes in the flow system are likely to move the plume in response.

Questions regarding this memo should be directed to Ms. Alice Campbell by contacting her at 818-717-6623 or acampbel@dtsc.ca.gov.

Figure 1, illustrating section from RZ-02 to OW-06

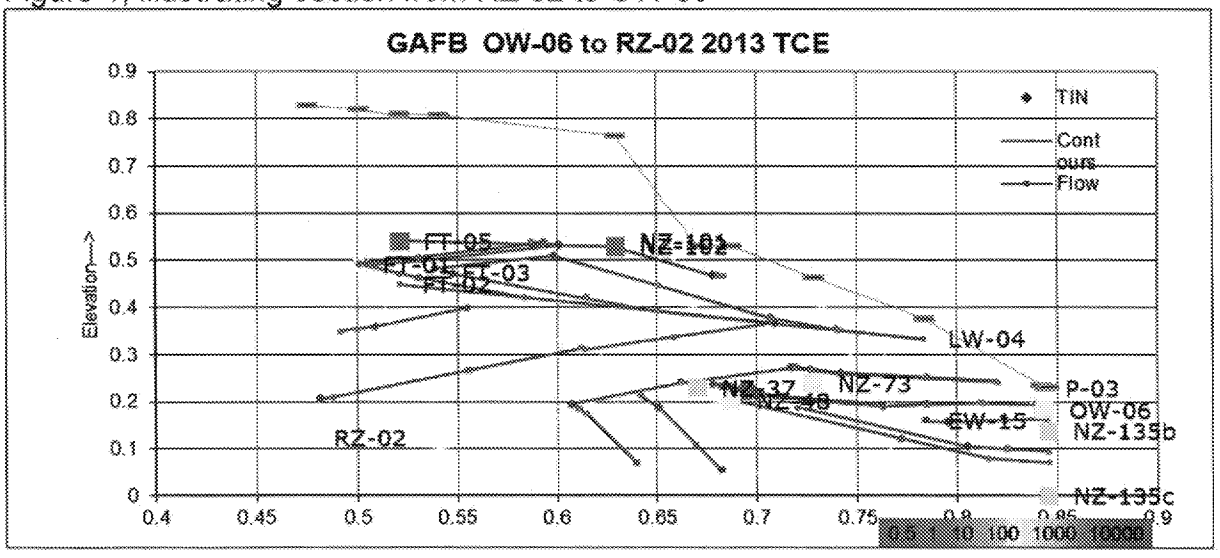


Figure 2, illustrating rise of groundwater into source zone at FT-05

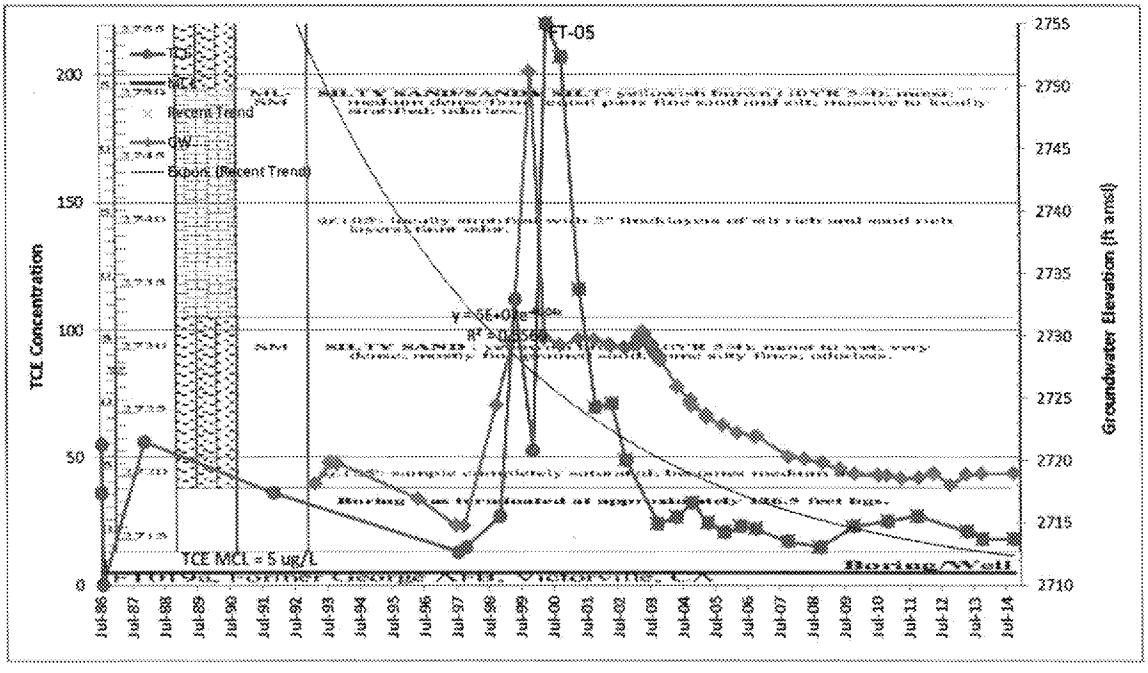


Figure 3. Figure illustrating effect of both water levels and high rainfall on TCE concentration.

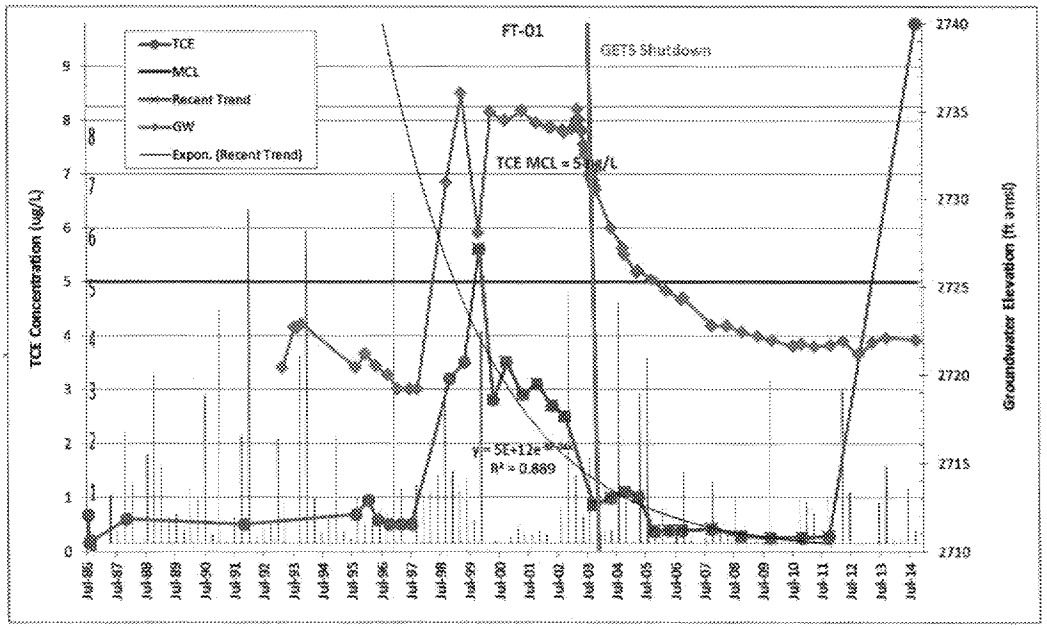


Figure 4, Pulse fit model showing concentration versus time for a pulse fit to data from FT-05. Error is less than 1%. Compare with exponential fit below:

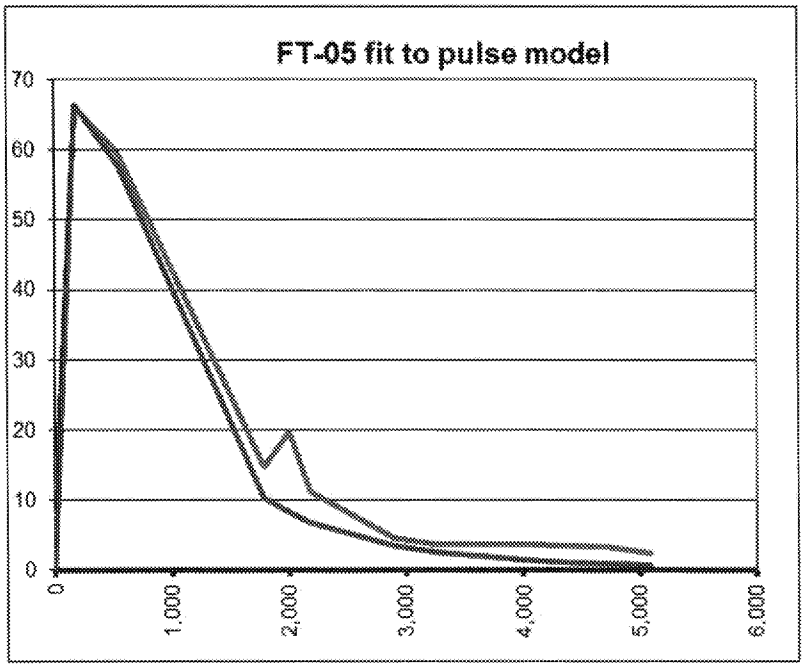


Figure 5, illustrating no obvious reason for exponential fit.

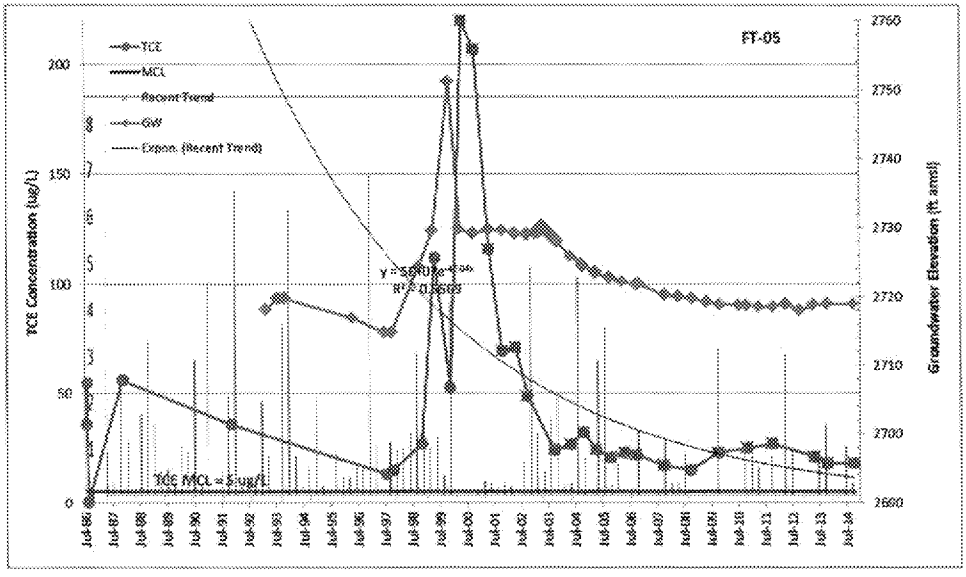
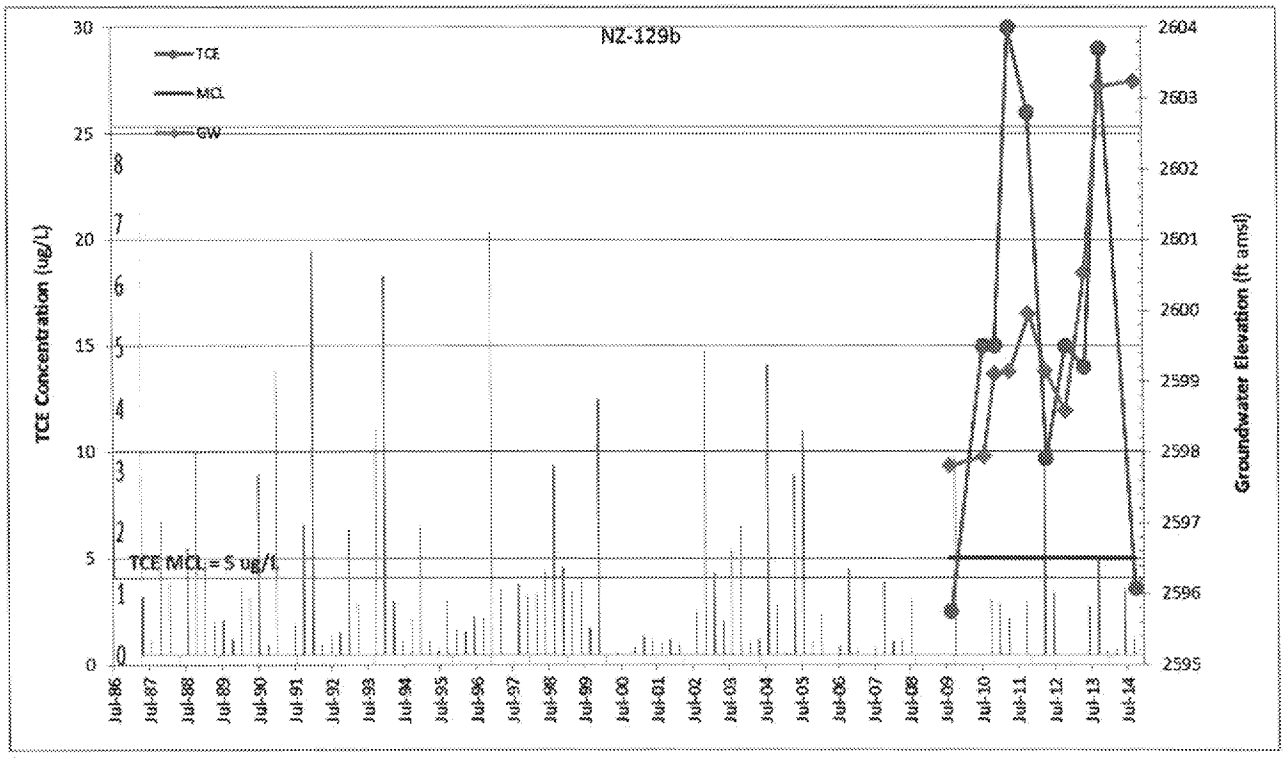


Figure 6, showing locally derived pulses passing by NZ-192b.



Stone, Linda@Waterboards

From: Campbell, Alice@DTSC
Sent: Monday, July 20, 2015 3:08 PM
To: Stone, Linda@Waterboards
Subject: RE: GeorgeAFB_MNA_OU1.doc

Hi Linda,

Here are some additional comments regarding the Conclusions section.

The conclusion that the plume is stable or shrinking has been addressed in several comments. The document argues that the shrinkage is the result of SVE treatment of the vadose zone, because biodegradation rates are insufficient to materially treat the plume. As we have stated, linking SVE operation with decreases in TCE in groundwater is problematic because in many instances shown on the time series, increases and decreases were triggered not by the timing of SVE operation but by the timing of increases and decreases in water levels. Comparing infiltration events as identified from rainfall records shows very few, short spikes in the upper aquifer associated with periods of heavy rain. Instead, ponding near source areas raised the water table into contaminated zone in the lower vadose zone. When the ponding ceased, the lower vadose zone drained, taking much contamination with it, and caused the 2002 peak in contaminant levels in the shallow zone. Generally dry climate conditions since 2002 have eliminated most infiltration through the vadose zone.

The FT109 and FT082 SVE systems targeted the shallow parts of the vadose zone, and not the lowest part near the water table. While shallow sources may have been affected, there is still much TCE in the deeper part of the vadose zone, the part that was saturated during the time that groundwater was ponded nearby. This is the source area most likely to produce additional pulses of contamination.

Drainage of water from the upper zone to the lower zone delayed the peak of the pulse from 2002 to 2009, consistent with fairly low transmissivities in the lower lacustrine layer restricting flow rates. The statement that 40 feet of head is lost between the lower and upper unit through the unsaturated vadose zone is a bit misleading, because true unsaturated flow is non-Darcian on several levels. The calculation in the fourth bullet point of Conclusion 3 is incorrect because there is no continuous saturation between the upper and lower aquifer.

The statement that TCE may be partitioning to soil is offered without any actual evidence. TCE does not sorb to silica, and the clays are carbon-poor, so only weak van der Waals forces could be invoked for sorption, and a saturated front would likely overcome them and remobilize the TCE. The statement has little technical justification, and it directly conflicts with the next bullet point. The following paragraph describes why.

The argument that Henry's law governs transport of TCE is based on partitioning between gas and water. But this conflicts with the statement that there is sorption to soil. Partitioning to soil would follow some kind of sorption curve or isotherm. Koc is usually used to describe partitioning to organic carbon, but the soils have very little carbon, so let us posit a Kclay as the partitioning between soil and water. Three-phase partitioning produces retardation analogous to retardation of VOCs in groundwater flow systems. Because a third phase is present, effective volatility is not governed by Henrys but by Henry's modified by Koc or Kclay. This means that effective volatility is orders of magnitude lower than TCE's Henry's constant. The calculation using Henry's is inconsistent with the previous bullet point. Note also that any TCE temporarily sorbed to soil, assuming this even happens, will eventually be released back to groundwater, it is retarded but not destroyed. A borehole into the vadose zone in the vicinity of the vertical conduits would confirm whether or not TCE is present in soil gas in the vadose zone. Otherwise, the conclusion is speculation unsupported by evidence.

The 30% porosity quoted in the calculation in Conclusion 5's second bullet point is incorrect. Densified alluvium has a drainable porosity of 10% or less. The difference in porosities is related to using typical soil values derived an old USDA study for plowed fields, where 30% porosity and a bulk density less than 100 pcf is reasonable. Bulk densities for compacted fills and deeply buried alluvium are generally higher than 110 pcf, and 30% porosity is impossible without assuming a very low specific gravity for the soil grains. Using a more reasonable porosity of 10%, the concentrations of TCE would be three times higher. However, the entire calculation is based on unproved assumptions and is inconsistent with the stated conceptual model.

Our comment 20 presents an alternative explanation, that there is little observed attenuation in the unsaturated zone between the upper and lower aquifers, and that the lower concentrations in the lower zone are caused by dilution of the small volume of leakage between the aquifers. The cross sections attached to the comments show little attenuation across the vadose zone between the upper and lower aquifer. The volatilization hypothesis is testable by installing vapor probes in the unsaturated zone, and measuring TCE in soil gas. Low TCE concentrations mean low volatility and a low *__effective__* volatilization rate because of retardation in the soil. A high TCE concentration in soil gas would mean a high *__effective__* volatilization rate with little retardation. If the missing TCE mass is not in the vadose zone, then it is still in the source zones, waiting for a saturation event to remobilize it.

Since the conclusion that MNA will be effective depends strongly on the volatilization idea, then hard data should be provided to prove it, or the conceptual model should be revised as described in the Comments.

Alice

From: Stone, Linda@Waterboards
Sent: Friday, June 26, 2015 10:44 AM
To: Campbell, Alice@DTSC
Subject: GeorgeAFB_MNA_OU1.doc

Hi Alice
This looks great. I added a few suggested edits and some clarifying comments for your consideration.
Thank you for all you support.
Also we had discussed you using our PCA code which is 16661.
The AF is dinging us for not using all the money they gave us.
Thanks
Linda

September 28, 2016

Don Gronstal
AFCEC/CIBW BRAC
3411 Olson Street
McClellan, CA 95652-1003
donald.gronstal@us.af.mil

Draft Five-Year Review Report, Former George Air Force Base, Victorville, San Bernardino County, dated June 2016

Introduction

The Water Board has reviewed the Draft Five-Year Review Report, Former George Air Force Base (Five-Year Review), which addresses CERCLA sites that are under the Operable 1 Record of Decision (OU1 ROD) and the Operable Unit 3 Record of Decision (OU3 ROD). The Water Board finds that the remedies of the two RODs do not provide long-term protectiveness. Evaluation of site data indicate that contaminant sources are continuing to impact groundwater and plume stability. At OU1, the trichloroethene (TCE) plume continues to migrate vertically to the lower, regional aquifer where it is spreading laterally. At OU3, the largest TCE plume, Site OT069e, is also continuing to migrate laterally and the vertical migration has not been investigated.

This letter conveys Water Board comments on the Five-Year Review. Please include Water Comments as an attachment or as part the final Five-Year Review Report. Comments from the Department of Toxic Substances Control, Human and Ecological Risk Office (HERO) on the risk assessment portion will be provided under a separate cover.

Comment 1: Section 4.0 Operable Unit 1 Sites

The Water Board is concerned that the Five-Year Review presents an unrealistic evaluation of the protectiveness and effectiveness of the continued shut down of the pump and treat system that was selected in Operable Unit 1 (OU1) for Site CG070 and of the Air Force's proposed new remedy of monitored natural attenuation (MNA) with institutional controls (ICs). Additionally, the document does not discuss or consider the Water Board's position that active remediation is feasible and MNA alone will not meet regulatory requirements. MNA is not adequate to remediate the contamination (primarily TCE) that extends over 700 acres, impacts two aquifers, and threatens the Mojave River and its

underlying aquifer and supply wells. Additionally, the 2012 Focused Feasibility Study, OU1 TCE Groundwater Plume (Focused FS) estimated the timeframe for achieving remedial goals for MNA is over 500 years, which is an unreasonable and unacceptable timeframe for restoration of the beneficial uses of groundwater, especially in an area of limited water resources such as the Mojave Desert and does not support long-term protectiveness .

The Water Board's position regarding the consideration of MNA in an amendment to the ROD has been conveyed to the Air Force in multiple communications, including 2014 letters on the Proposed Plan in which the Air Force first put forth MNA as its preferred remedy, and most recently, an August 2016 letter, which stated:

> The Air Force's plan to go forward with a ROD amendment for a new remedy (i.e., MNA) that the Water Board does not accept is neither productive nor reasonable, and indicates that the Air Force is unwilling to work with the Water Board in good faith to resolve these issues. If the Air Force continues to propose MNA without additional active remediation, the Water Board will be forced to dispute the ROD amendment, which will result in protracted delays. These delays could allow continued groundwater degradation and contaminant migration, potentially increasing the time and cost to achieve cleanup goals and delay restoration of the beneficial uses of groundwater resources. These outcomes are not in the best interest of the federal government or of the people of the State of California.

However, the Five-Year Review does not acknowledge the Water Board's position and, instead, presents a highly unrealistic timeframe of 2017 for the adoption of an amendment to the ROD for MNA with ICs, completion of the remedial design, and implementation of the remedy. The lack of regulatory acceptance represents a significant impediment to the adoption the proposed amendment to the ROD, and the fact that the Five-Year Review does not acknowledge the Water Board technical concerns and its position that active remediation is necessary to comply with regulatory requirements, represents a significant deficiency.

Because of the continued contaminant migration in the Lower Aquifer and the threat it poses to the Mojave River, its aquifer and supply wells, it is imperative that active remediation and an adequate monitoring network be put in place as soon as possible. Further delays, such as those caused by the Air Force's failure to work with the Water Board in good faith during the remedy selection process, will make site remediation more technically challenging, more costly for the federal taxpayers, and deny the citizens of the state access to this water resources for the foreseeable future.

Comment 2: Section 3.6 Geology and Hydrogeology

This section's statement regarding a percolation route from the Upper Aquifer to the Lower Aquifer should be revised to more clearly state that there is a zone west of the bluffs were the perching zone becomes discontinuous and allows migration from the Upper Aquifer to the Lower Aquifer.

Comment 3: Section 3.6 Geology and Hydrogeology

The last sentence of the seventh paragraph in this section states that as a result of groundwater mounding caused by the Victor Valley Wastewater Reclamation Authority (VVWRA) infiltration ponds, the Lower Aquifer discharges to the Flood Plain Aquifer and the side channels of the Mojave River in the vicinity of VVWRA. This statement contradicts the first sentence of that paragraph, which more accurately characterizes the effects of the VVWRA mounding that causes groundwater to flow radially away from the mound to the north, west, and south. Please revise the sentence accordingly.

Comment 4: Section 3.9 Water Use and Well Inventory

This section asserts that there are no current users of the Upper Aquifer and that there are no groundwater users within the area of groundwater contamination. Please reference or describe all Air Force efforts that are the basis of this statement, including field verification.

Comment 5: Section 3.9 Water Use and Well Inventory

The Water Board appreciates the Air Force's efforts to rectify prior misrepresentations regarding the VVWRA water supply wells. However, this section seems to imply that the water from these wells is not used for drinking water. The text should be revised to reflect the fact that, although bottled water is available at VVWRA, there are no restrictions or prohibitions against drinking the water from faucets and taps at the facility because the wells are used as the potable water supply. Therefore, workers and visitors may, in fact, be using the well water for drinking water. The VVWRA wells also provide the water for the adjacent facility, American Organics, which the Water Board understands, also makes bottled water available. Finally, the Five-Year Review refers to these wells inconsistently in this report as production wells, in-plant use wells, and water supply wells. Please revise the text to consistently refer to the wells as water supply wells.

Comment 6: Section 3.9 Water Use and Well Inventory

The statement that Victorville Federal Correction Complex would have to construct a water treatment plant to remove arsenic from groundwater prior to use as water supply wells is incorrect. Water quality data from the wells demonstrate that arsenic levels are below the maximum contaminant level (MCL) and the facility manager informed the Water Board that there are no plans to install a treatment facility prior to using the wells for water supply. The current Division of Drinking Water's status for the wells is "inactive." Please revise the text to reflect this comment.

Comment 7: Section 4.1, Recommendations From Third Five-Year Review Report

The discussions of status under first three bulleted items in this section should be revised to acknowledge that the Water Board did not accept the Proposed Plan and does not concur with the Air Force proposed remedy, i.e., MNA with ICs. See Comment 1. Until there is at least conceptual agreement on remedy components that would achieve regulatory concurrence, the estimate 2017 timeframe for completion of a record

of decision amendment discussed in the first bulleted item is unrealistic and there is a high level of uncertainty associated with the follow-up items described under the second and third bulleted items. The status of resolving outstanding issues should be discussed in the Five-Year Review and considered when estimating time of completion of the various steps.

Comment 8: Section 4.1, Recommendations From Third Five-Year Review Report

The Water Board does not agree with the discussion of status under the fifth bulleted item in this section. Specifically, the Water Board finds that the Air Force has not adequately monitored changes caused by infiltration from VVWRA's discharges and that additional monitoring wells are necessary. See Comment 18.

Comment 9: Section 4.2 Site CG070 Description and Background

The Water Board does not concur with the assertion that the plumes are stable and concentrations are decreasing. See Comment 19.

Comment 10: Section 4.3.2 Remedy Implementation

The text states that one of the sewage treatment plant (STP) ponds was used for disposal of debris at the time of base closure. The text should describe what removal actions were taken in response to this disposal and reference the document that describes these actions. Also see Comment 16 regarding possibility that the STP are a continuing TCE source for CG070 and the occurrence of PFCs in soil samples. Finally, the text states that the STP ponds are to be destroyed by SCLAA. It is not clear why SCLAA is responsible for "destroying" the ponds. If the ponds received other kinds of waste in addition to sewage, they may be subject to closure requirements of California Code of Regulation title 27 requirements.

Comment 11: Section 4.3.2 Remedy Implementation

This section states that after the pump and treatment system was shut down, it was determined that optimization of the system would not be effective. However, earlier documents recommended optimization and use of the system. Please specify where the determination that optimization would not be effective and regulatory concurrence of this determination were documented.

Comment 12: Section 4.3.2 Remedy Implementation

The discussion of the 2012 Focused FS should be included under Section 4.3.4, *Progress Since the Last Five Year Review*, rather under *Remedy Implementation*.

Comment 13: Section 4.3.4 Progress Since the Last Five-Year Review

This section does not discuss two significant documents that have been issued by the Air Force since the last Five-Year Review, i.e., Focused FS and Technical Memorandum, Evidence for Natural Attenuation, Site CG070, Operable Unit 1 (Tech Memo). These documents and the regulators' acceptance should be discussed in this

section. Although the Proposed Plan is briefly discussed, this section should be revised to include a discussion of the regulators' non-concurrence with the Proposed Plan.

The Focused FS evaluated various alternatives, it did not recommend or select a remedy. The regulators accepted Focused FS as adequate to move the remedial selection process forward even though there were still outstanding concerns (e.g., evaluation of feasibility of achieving background levels). The Proposed Plan, which put forth MNA with ICs as the Air Force's preferred remedy, was not accepted by the Water Board primarily because the Focused FS estimated it would take over 500 years to achieve cleanup goals using MNA. In response to Water Board's concerns regarding the unreasonably long cleanup timeframe, the Air Force issued the Tech Memo, which used different assumptions and methodologies that resulted in a shorter estimated cleanup timeframe than the Focused FS. The Water Board does not concur with the technical evaluation or conclusions of the Tech Memo. The Air Force's issuance of the Tech Memo and Water Board's non-concurrence should be mentioned here.

Comment 14: Section 4.4.2 Risk Information

The Water Board does not agree with the statement that "the Upper Aquifer is not a viable source of potable water." The aquifer has designated beneficial uses include municipal and domestic water supply and the aquifer serve as a domestic water supply. Additionally, it is not clear that the Air Force has established that there are no users of the Upper Aquifer. See Comment 4. Therefore, the contaminated groundwater of the Upper Aquifer should be included in a revised risk assessment.

Comment 15: Section 4.4.2 Risk Information

There is currently no effective prohibition on residential uses in offsite areas. Please revise the text to describe surrounding uses in offsite areas where there is a potential risk via indoor air pathway.

Comment 16: Section 4.4.3 Data Review

The Air Force has not demonstrated that all sources have been remediated to the extent that they are not contributing to groundwater contamination and that they do not represent a future threat to groundwater quality. Source control is a particularly critical issue for the Air Force's remedy implementation since any remaining sources will significantly lengthen the cleanup timeframe, could cause further plume migration, and introduce unacceptable uncertainties for remedy protectiveness.

There appear to be continuous and on-going, low-level releases of contaminants to groundwater. For example, the three monitoring wells that define the southern plume core of the Upper Aquifer, NZ-54, NZ-68, and NZ-51, all show relatively low, but increasing trends. The southern plume core is centered under the STP ponds (Site WP026) and the adjacent High Desert Power Plant (FT020). Further characterization and evaluation are needed to determine the cause of the increasing trends at this location and if source control measures at WP026 and FT020 are necessary.

Additionally, a recent Air Force study detected the fire retardant compounds, perfluorooctonoic acid (PFOA) and perfluorooctane sulfonate (PFOS), in soil samples at CG070 source areas (including the vicinity WP026 and FT020) and in the underlying groundwater. The current known extent of PFOA and PFOS in soil and groundwater should be discussed in this section.

Comment 17: Section 4.4.3 Data Review

Please clarify why 2015 data were included for nitrate but not for TCE.

Comment 18: Section 4.4.3.1 Extent of Contamination

The monitoring network is not adequate to delineate the extent of impacts in the Lower Aquifer, especially since VVWRA began discharging to its southern infiltration ponds in 2001. Prior to the use of the ponds, groundwater flow in the Lower Aquifer was to northeast and the Mojave River. The ponds created a very extensive groundwater mound, which drives site groundwater radially to the north, west, and south. Because of the change in flow direction, many formerly downgradient wells are now upgradient and there is inadequate delineation of contamination in the downgradient directions.

Additionally, there are no monitoring wells between the two hot spot wells, NZ-107 and NZ-84, which are over 2,000 feet apart. Therefore, the extent of the elevated TCE concentrations detected in the two wells is not known and contamination may exist as a single area of contamination as shown in monitoring reports prior to 2012 rather than two discrete areas as currently interpreted by the Air Force.

The most northern area of groundwater contamination is monitored by a single well, NZ-72. It has been monitored since 1994 and TCE was mainly non-detect until 2013 when there was a sudden increase in concentrations. The Air Force plans on installing additional wells in this area. Adequate delineation is critical to the evaluation of stability and protectiveness since the regional flow in this portion of the site is still toward the Flood Plain Aquifer and the Mojave River.

Comment 19: Section 4.4.3.2, Plume Stability

The Water Board does concur that the plumes are stable. Water Board's review of the data indicate there is continued contaminant migration from the Upper Aquifer to the Lower Aquifer and the continued plume migration in the Lower Aquifer that is not being adequately monitored by the existing monitoring network.

<u>Upper Aquifer Stability</u>.

The Water Board accepts that the Air Force has demonstrated that the Upper Aquifer's commingled plume is primarily stable laterally at the maximum contaminant level (MCL) for TCE. However, a significant factor in the lateral stability of the Upper Aquifer plume is the fact that the perching zone that creates the Upper Aquifer pinches out in the direction of groundwater flow (northeast). Contaminated groundwater from the Upper Aquifer migrates downward at the eastern and northern edges of the perching zone and into the Lower Aquifer. This creates an apparent stability, but in fact the groundwater

contamination continues to migrate vertically down and into the Lower Aquifer. Based on this continuing contaminant migration into the Lower Aquifer and the increasing TCE trends in the Lower Aquifer, the Upper Aquifer plume cannot be considered *vertically* stable and it is acting as a continuing source of Lower Aquifer contamination.

Additionally, a recent Air Force study found concentrations of PFOS and PFOA in the Upper Aquifer plume were almost two orders of magnitude above the USEPA health advisory. The extent of impacts and stability of these highly mobile and recalcitrant contaminants have not been determined and represent significant uncertainties.

Lower Aquifer Stability.

The Lower Aquifer is clearly not stable and because of the inadequate monitoring network, the Air Force cannot support its statement that the Lower Aquifer plume has decreased in size. Although the existing monitoring network is inadequate to delineate the extent of groundwater impacts, evaluation of the current groundwater flow regime and increasing TCE concentrations in many of the Lower Aquifer wells, indicate that contamination is migrating away from the monitoring network to the north, west, and south, and is causing further degradation of this water supply aquifer.

Finally, concentrations of PFOS and PFOA in the CG070 plumes are one order of magnitude above the USEPA Health Advisory in the Lower Aquifer. The extent of impacts and stability of these highly mobile and recalcitrant contaminants in the Lower Aquifer have not been determined and remain uncertainties.

Comment 20: Section 4.4.3.2. Plume Stability Subheading Stable or Declining TCE Concentrations, Lateral and Vertical Plume Stability.

The text states that the Water Board recommended the use of the triangulated irregular network (TIN) method for contouring plumes. The Water Board comment letter (dated August 10, 2015) on the Draft Tech Memo included technical comments by Department of Toxic Substances Control (DTSC), Geological Services Units (GSU). GSU's Comment #28, which is repeated below.

> There is little consistency or rigor in contouring groundwater, delineating plumes, or fitting trends to the data. This reduces confidence in the figures, and makes the results more an opinion and less of a technical result. GSU has asked that the groundwater be contoured using TIN, which produces repeatable and consistent contour maps. GSU has advocated drawing flow lines over the contours and using the flow lines to outline plumes. This method produces highly consistent plume maps that honor the data and are repeatable for the same dataset problems with well network, not sampling high concentration wells.

To further clarify the comment as steps, GSU was recommending the following process

1) Use the TIN method to contour groundwater elevations,
2) Draw flow lines based on groundwater elevation contours.
3) Consider the flow lines when constructing isoconcentration contours for plume delineation.

The Water Board does not object to using TIN directly to construct groundwater isoconcentration contours, but would like to clarify that GSU recommends the method as described above. Additionally, while use of the TIN method is acceptable to the Water Board because it is not subjective and it provides a more consistent basis for evaluation over time, it's outputs are the result of the spatial distribution of sample locations and it can produce unrealistic contours if the monitoring network is inadequate or as a result of changes in the sample locations over time. Therefore, changes in the monitoring network should be considered when making conclusions regarding changes in plume configuration over time. The Air Force's evaluation of changes in plume configuration does not include an evaluation of changes in monitoring network, which is necessary to support its conclusions regarding changes in plume configuration over time.

Comment 21: Section 4.4.3.2. Plume Stability, Stable or Declining TCE Volume of Impacted Water

The supporting calculations for the analysis of volume were not included. Therefore, the Water Board cannot comment on this analysis or accept its conclusion except for the assumption stated on Table 4-4, which reports the calculated volumes. The assumption on that table states that a saturated thickness of 50 feet was assumed for both the Upper Aquifer and the Lower Aquifer. However, there have been significant changes in water levels in many monitoring wells over that period. For example, Upper Aquifer well, NZ-98, increased by almost 17 feet, representing a 30 percent increase in saturated thickness. Lower Aquifer well, NZ-69, increased approximately 24 feet during that period, representing an increase in thickness of almost 50 percent. Assuming a uniform saturated thickness overtime will result in an apparent decrease in impacted volume that is actually a result in dilution from an increased saturated thickness. Also the increasing groundwater levels in the Lower Aquifer are the result of discharges to VVWRA's infiltration ponds, which has caused the groundwater flow direction to shift and in some case to reverse. The current monitoring network does not adequately monitor the downgradient impacts under the current flow regime, which would result in underestimating the volume of impacted groundwater. See Comments 19, 20, and 21.

Comment 22: Section 4.4.3.3. Mass Estimates of Contaminated Groundwater

The methods and assumptions used to calculate mass are not included so the Water Board cannot comment in detail on this analysis. However, prior Water Board comments on the plume volume calculations, limitation of TINs, and the adequacy of the monitoring network (Comments 18, 20, and 21) apply to this section. Changes in the monitoring network should also be considered. For example, Upper Aquifer monitoring wells with the highest concentrations in the early 2000s, i.e., NZ-40, NZ-55, NZ-82, and NZ-83, have not been sampled since 2004. If these wells were included in the earlier sampling events but not the later, mass estimation could skew the results to show an unsupported decrease in mass over time in the Upper Aquifer. Additionally, using a three year average rather than annual results could be helpful to show more meaningful changes in plume configuration over time.

Comment 23: Section 4.4.3.4 Nitrate in Groundwater

The conclusions regarding nitrate should be qualified since there appear to be so little data that it is difficult to determine trends over time and extent of contamination. Please clarify why no nitrate data are included from the time period between 2006 and 2014.

Comment 24: Section 4.4.3.4 Nitrate in Groundwater

Water Board does not concur with this section's assertion that the rise in water levels is responsible for increase in nitrate and that nitrate will decrease when groundwater levels decrease. This appears to be a new conclusion and no supporting evidence is provided or referenced. And even if true, future rises in groundwater levels may result in increased nitrate concentrations and require remedial actions.

Comment 25: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents?

The discussion in this section is incomplete since it only discusses land use controls that are not part of the remedy selected in the OU1 ROD. The 1994 OU1 ROD estimated the selected remedy, pump and treat, would take 30 years to achieve cleanup goals (that is, cleanup goals would be achieved in the year 2024). The pump and treat system was shut down for optimization in 2003 after nine years of operation and never restarted. Historically, the MCL boundary of the CG070 the plume extended into the Flood Plain Aquifer in the vicinity of VVWRA. The maximum TCE detected was 17 µg/L in Flood Plain Aquifer well, LW-2, in 1994. The leading edge of the plume in this area was largely pulled back by the operation of the pump and treat system and concentrations were reduced to below the MCL by 1999. The text should be revised to discuss the recommendations of the optimization study and the Air Force's justification for the continued non-operation of the remedy.

The shutdown of the pump and treat system for over 12 years has allowed continued migration from the Upper Aquifer to the water supply aquifer (i.e., Lower Aquifer) and migration of contamination in the Lower Aquifer continues to spread beyond the existing monitoring system, further impacting the beneficial uses of the water supply aquifer. The Water Board finds the discussion of ICs inadequate, since they will not result in restoration of the beneficial uses of groundwater and will not prevent continued migration in the Lower Aquifer or predicted impacts to the Flood Plain Aquifer and surface waters of the Mojave River after cessation of the VVWRA discharges Also see following Comment 26.

Comment 26: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Implementation of Institutional Controls and Other Measures

The proposed ICs described under the heading "On Base" may be adequate to prevent the installation of additional wells within the boundaries of Former George Air Force Base (GAFB) in some but not all land transfers. For example, the memorandum of understanding (MOU) for the transfer of the southern portion of GAFB to the Federal

Bureau of Prisons did not preclude the 1998 installation of groundwater wells buy the Bureau of Prisons in an area adjacent to a GAFB pesticide plume (Site OT071) and a nearby GAFB petroleum plume (ST067b). Not only do these wells represent potential receptor points, but the wells were constructed in such a way that they act as vertical conduits for groundwater migration from the Upper Aquifer to the Lower Aquifer. To date, the neither the Air Force nor the Bureau of Prisons has properly abandoned the two wells nor are we aware of amendments to the MOU that prohibit future well installations on this portion of GAFB.

Comment 27: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Implementation of Institutional Controls and Other Measures

The transfer of the former residential portion of GAFB to the City of Victorville included a prohibition against ground disturbances that could result in human exposure to pesticide contaminated soils. The discussion of ICs under the subheading "On Base" states that, in response to unauthorized digging that occurred at Site OT071, the Air Force established a formal review/coordination process in April 2015 and a Joint Strategic Planning and Redevelopment Forum which includes regulators. Please specify what entities are members of this forum, how often it meets, where the "formal review/coordination process" is documented, and how this process assures appropriate implementation of ICs.

This section also discusses how an on-site field representative for the Air Force monitors SCLAA's activities and who considers and documents compliance with existing land-use restrictions. However, the unauthorized digging incident described in this section was brought to the attention of the Air Force by Water Board staff (letter dated September 18, 2015) and there have been ground disturbances actions, i.e., building demolish and construction of a paint ball field that have not been prevented by the Air Force. Please briefly describe and reference any enforcement mechnisms that have been put into place to assure future compliance, including after transfer of GAFB is complete and there is no longer an onsite Air Force representative.

Comment 28: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Implementation of Institutional Controls and Other Measures

Under the subheading of "Off Base" the text states that the Air Force is in close communication with VVWRA regarding its "plant-use wells." Until the recent, May 2016 Tech Memo, Air Force documents did not include these supply wells on figures of wells in the vicinity of GAFB. The wells are the water supply source at VVWRA both for human consumption and industrial purposes.

Comment 29: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Implementation of Institutional Controls and Other Measures

Approximately half of the CG070 plume extends off site. The text states a Notification Zone involving the County of San Bernardino and the City of Victorville will be used to limit the installation of wells in areas above or in the vicinity of the CG070 TCE plume. However, the Notification Zone does not provide a sufficient basis to support that there are adequate ICs in place to protect potential receptors because they are not actual legally enforceable rules or ordinances. The proposed ICs represent reasonable steps; include zoning ordinances, which can be changed; Consultation Zones, that are unenforceable; a well permitting process that is contingent upon a consultation process with other agencies that relies on those other agencies to maintain an internal processes to identify potentially contaminated areas; and a building permit process that does not have the ability to prohibit the installation of wells based upon their location. However, these mechanisms cannot be relied on as the sole mechanisms. For the non-Air Force owned properties there are no proprietary controls, such as a deed restriction. Please describe any efforts or discussions by Air Force to secure proprietary controls on the non-Air Force owned sites.

Comment 30: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Implementation of Institutional Controls and Other Measures

The discussion of ICs should include a summary of the land use controls for the FOSET in progress for transfer of off-base Parcel L-1.

Comment 31: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

The Water Board disagrees with the assertions in the second item under the first bullet that there is a comprehensive understanding of the migration pathways, plume extent and potential receptors. See Comments 18, 19, 20, and 21.

Comment 32: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

The third item under the first bullet implies the VVWRA wells are not used for drinking water should be modified in accordance with Comment 5.

Comment 33: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

Water Board disagrees that the remedial action objective (RAO) of reduction of TCE concentrations in groundwater to below the MCL of 5 micrograms/liter (µg/L) is being addressed since the pump and treat system was turned off in 2003. The Focused FS estimated that MNA would require over 500 years to reach the MCL and this timeframe is not acceptable to the Water Board. Active remediation is necessary to restore

groundwater to its beneficial uses and prevent further migration and potential impacts to receptors.

Comment 34: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

The Water Board does not agree with the assertions regarding plume stability. See Comments19, 20, and 21

Comment 35: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

The discussion in this section does not address the relevant question, i.e., is the remedy functioning as intended. The 1994 OU1 ROD estimated that it would take 30 years (the year 2024) to achieve cleanup goals using the selected remedy of pump and treat. The pump and treat system was shut down for optimization in 2003 after 9 years of operation and never restarted. The pump and treat remedy provided plume control while in operation. Based on the Focused FS MNA it will take 500 years to achieve cleanup goals at CG070. The disparity between the performance predicted in the OU1 ROD, and the intended performance for the proposed MNA remedy should be discussed under this heading.

Comment 36: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

Water Board disagrees with the following conclusions under the discussion of the RAO to eliminate or reduce the potential for further migration of the groundwater contamination.

- The Water Board does not agree with Air Force's assertion that compliance with this RAO has been achieved. See Comments 19, 20, and 21
- Water Board disagrees with the assertion that all vadose zone source areas are controlled. See Comment 16.
- Water Board disagrees with the assertion that the extent of and magnitude of contamination have been defined in the Lower Aquifer. See Comment 18.
- Water Board disagrees with the assertion that the plumes are stable in the Lower Aquifer. See Comments 19, 20, and 21.
- The Water disagrees with the assertion that the Air Force's current monitoring is adequate to ensure compliance with this RAO. See Comments 18 and 25.

Comment 37: Section 4.5.1 Question A: Is the remedy functioning as intended by the decision documents? Remedial Action Performance

The Water Board does not agree with the assertion that an expansion of the pump and treat system is not needed. Continued monitoring with no active remediation will not restore the beneficial use of the groundwater resources and will allow the contamination

to represent continuing threats to groundwater users and the Mojave River for hundreds of years.

Comment 38: Section 4.5.1 Question A: Is the remedy functioning as intended by the decision documents? System Operations/Operations and Maintenance

This section states that "It became clear that optimization" of the pump and treat remedy would not be effective." Please provide the supporting justification for this statement or reference the document that contains the analysis supporting this statement.

Comment 39: Section 4.5.1 Question A: Is the remedy functioning as intended by the decision documents? System Operations/Operations and Maintenance

This section should acknowledge that the Water Board did not concur with the remedy proposed of MNA in the Proposed Plan and as stated in Comment 1 the Water Board does not concur the Air Force evaluation and conclusions regarding the effectiveness and protectiveness of MNA at CG070 and does not support the issuance of a ROD amendment for MNA with ICs (Water Board letter dated August 5, 2016). Based on the lack of regulatory concurrence, the estimate 2017 timeframe for completion of a record of decision amendment, remedial design, and implementation of the remedy is highly unrealistic.

Comment 40: Section 4.5.1, Question A: Is the remedy functioning as intended by the decision documents? Early Indications of Remedy Failure

The change of the selected remedy to MNA, as proposed by the Air Force, does not have State acceptance, is not protective, and will not result in restoration of the beneficial uses of groundwater in 500 years. Therefore, there is high likelihood the propose remedy, if put forth, will fail in attaining RAOs.

Comment 41: Section 4.5.1, Question B: Are the assumptions used at the time of the remedy selection still valid? Changes in standards and to be considered.

The federal standard for nitrate should be included as a cleanup standard. Additionally, State Water Resouces Control Board Resolution 92-49 requires cleanup to background conditions.

Comment 42: Section 4.5.2, Question B: Are the assumptions used at the time of the remedy selection still valid? Changes in Exposure Pathway.

Water Board does not agree that groundwater use is effectively prohibited, and therefore, there is no exposure route for groundwater. See Comments 26, 27, 28, and 29.

Comment 43: Section 4.5.3. Question C: Has any other information come to light that would call into question the protectiveness of the remedy.

The cessation of VVWRA discharges will allow plume migration to the Flood Plain Aquifer, VVWRA supply wells, and the Mojave River. VVWRA has begun reducing discharges and may cease as early as the summer 2017. The document states that it

will take 6 to 8 years for the mound to dissipate based on the time it took for NPP groundwater mounds to dissipate in the Upper Aquifer. This statement is highly speculative. Conditions in the Lower Aquifer and Flood Plain Aquifer are very different from the Upper Aquifer and the quantity and nature of VVWRA discharges are also different from the NPP. This statement should be supported by site specific modeling. This is a critical protectiveness issue since there are no measures in place to prevent the migration of the plume toward the Mojave River, Flood Plain Aquifer, and water supply wells once the discharges cease.

Comment 44: Section 4.5.3. Question C: Has any other information come to light that would call into question the protectiveness of the remedy.

A recent Air Force study detected the fire retardant compounds, PFOA and PFOS, in soil samples at CG070 source areas and in the underlying groundwater. PFOS and PFOA in the Upper Aquifer plume were almost two orders of magnitude above the USEPA health advisory and one order of magnitude above the advisory in the Lower Aquifer. The extent of impacts and stability of these highly mobile and recalcitrant contaminants have not been determined and represent significant uncertainties for the protectiveness of the proposed remedy. The Five-Year Review should be revised to discuss this emerging contaminant, how the potential extent of PFOA and PFOS contamination will be assessed, including recommendations and a timeframe to address the recommendations.

Comment 45: Section 4.6 Site CG070 Issues

The USEPA's 2001 Comprehensive Five Year Review Guidance states that "unresolved concerns or items raised by support agencies and community" should be discussed under this heading. This section should be revised to include such a discussion. See Introduction and Comment 1 regarding the Water Board's stated position and summary of concerns.

Comment 46: Section 4.6 Site CG070 Issues

The Water Board does not agree with the Air Forces assertions regarding the following issues.

Issue 2. Water Board does not agree that the current ICs are adequate to protect against the use of TCE contaminated groundwater from Site CG070 over the long term. See Comments 26, 27, 28, and 29.

Issue 3. Water Board does not agree that the planned cessation of VVWRA discharges does not impact the current protectiveness of the continued non-operation of the selected remedy. See Comment 43.

Comment 47: Section 4.6 Site CG070 Issues

Major site issues discussed under this heading should include the following.

- The selected remedy of pump and treat is no longer in operation and contaminant migration is uncontrolled and spreading vertically down into the

Lower Aquifer and migrating in the Lower Aquifer. The Lower Aquifer plume has migrated beyond the current monitoring network and is impacting previously unimpacted groundwater.

- The extensive groundwater contamination, its continuing migration, and cleanup timeframe estimated for the proposed MNA remedy represent continuing unacceptable impacts to existing and anticipated future beneficial uses of groundwater, and threats to human health and the environment.
- The extent of impacts in the Lower Aquifer has not delineated under current conditions.
- The expected cessation of VVWRA discharges in 2017 will allow contaminant migration to the Flood Plain Aquifer, water supply wells, and the Mojave River. There is currently no mechanism in place to protect these receptors and it is not clear that the current monitor program is adequate to evaluate this threat.
- The threats to human health and the environment from PFOA and PFOS in site groundwater have not been evaluated and remain significant uncertainties.
- Current ICs on property transferred to the Federal Bureau of Prisons failed to prevent to the installation of water supply wells. These wells not only represent a failure of the ICs that the Air Force proposes on relying on for hundreds of years, but also are vertical conduits between the Upper and Lower Aquifers that are allowing or could allow contamination migration into the water supply aquifer.
- For non-Air Force owned properties the Air Force is proposing unreliable and untested ICs to prevent the use of contaminated groundwater for human consumption. Therefore, MNA with the proposed ICs is not protective of human health, especially considering the existing problems with enforcement of ICs and that these ICs would have to be maintained for hundreds of years.
- The current ICs are inadequate to prevent infiltration sources that could influence plume migration, such as the leaking City of Victorville pond which are creating a groundwater mound and potentially spreading dieldrin contamination in groundwater (Site OT071).

Comment 48: Section 4.6 Site CG070 Issues

The reference to VVWRA NPP is incorrect. The NPP are the GAFB "new percolation ponds," which were used as part of the pump and treat system and not the same as the VVWRA infiltration ponds. Please revise the text accordingly.

Comment 49: Section 4.7 Site CG070 Assessment

Water Board does not agree with the Air Force's assessment of CG070, specifically,

- The Water Board does not agree that the lateral and vertical extent of the groundwater plumes are stable or decreasing. See Comments 19, 20, and 21.

- The Water Board does not agree that potential receptors are currently protected. See Comments 18 and 43
- The Water Board does not agree that long-term monitoring is sufficient to protect ecological receptors. See Comment 43

Comment 50: Section 4.8 Site CG070 Recommendations and Follow-up Actions

Water Board does not concur with the that the planned amendment to the ROD will provide long-term protectivenss and compliance with RAOs. See Comment 49.

Issue 1. Water Board does not concur that the planned amendment to the ROD changing the remedy from pump and treat to MNA with ICs will achieve ROAs and meet regulatory requirements as stated in Water Board letter dated August 5, 2016. Proposing a ROD amendment for a remedy that does not meet state requirements does move the project forward.

Issue 2. Water Board does not agree that the current ICs are adequate to prevent the use of CG070 groundwater containing TCE above the MCL. This is especially true for the offsite portion of the plumes. See Comments 26, 27, 28, and 29.

Issue 3. Water Board does not agree with the assertion that cessation of VVWRA discharges does not impact the current protectiveness. See Comment 43.

Comment 51: Section 4.8 Site CG070 Recommendations and Follow-up Actions

This section references revised RAOs. Please include the revised RAOs and specify where they were documented.

Comment 52: Section 4.9 Protectiveness Statement

The Water Board does not agree with the assertion that the proposed remedy of MNA with ICs is protective over the long term because it would require prohibitn the use of valuable water resources and important recharge storage capacity of the aquifer for many decades, potentiaally affing water usage rights for off-base propertiy owners. Groundwater contamination extends over 700 acres, impacts two aquifers, and threatens the Mojave River, the Flood Plain Aquifer, and water supply wells. Currently, there is no active remediation, inadequate monitoring, and no mechanism to prevent anticipated migration to human and ecological receptors.

Comment 53: Section 5.1 Recommendations from Third Five-Year Review, All OU3 Sites

It appears the recommendation for the last "status" heading on Page 5-4 is missing or there is a formatting error that caused it to be included in the preceding status discussion. Please rectify.

Comment 54: Section 5.4.3.3 Data Review

The data review should discuss the impacts from the emergent contaminants, PFOA and PFOS detected in FT019 soil.

Comment 55: Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

A recent Air Force study detected the fire retardant compounds, PFOA and PFOS, in soil samples at FT019 and in the underlying groundwater. The Five-Year Review should discuss these emerging contaminants, how the potential extent of PFOA and PFOS contamination will be assessed, including recommendations and a timeframe to address the recommendations.

Comment 56: Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

The mislocation of the soil vapor extraction (SVE) system at the FT019c and how this will be addressed should be discussed under this question.

Comment 57: Section 5.4.5 Site FT019 Issues

The mislocation of the FT019c SVE system should be included as an issue that impacts the remedy's protectiveness.

Comment 58: Section 5.4.5 Site FT019 Issues

The first issue should be modified to state that remediation is required to mitigate site risks *and threat to groundwater*.

Comment 59: Section 5.4.7, Site FT019 Recommendations and Follow-up Actions

This section recommends the implementation of the optimization work plan. However, since then, the Air Force has discovered that the remedial system was mislocated. This mislocation must be addressed and considered prior to the optimization effort. This section should be revised to include recommendations and follow-up actions for this issue.

Comment 60: Section 5.4.8 Site FT019 Protectiveness Statement

The protectiveness statement should be revised to include the uncertainties introduced by the mislocation of the remedial system.

Comment 61: Section 5.5.1, Site OT069 Description and Background, Historic

Please provide the information or reference the document that supports the statement that wells completed to the base of the Upper Aquifer contain no contaminants of potential concern.

Comment 62: Section 5.5.1, Site OT069 Description and Background, Historic

Please clarify what is meant by the statement that the source area of SD025, the Industrial Storm Drain is "inactive."

Comment 63: Section 5.5.2.1 Remedy Selection

The 1998 OU3 ROD estimated that the time to reach cleanup goals using MNA for the OT069e groundwater plume was 46 years, (i.e., 2044). A modeling effort was conducted in 2009 because concentrations were not declining as predicted in the ROD. The 2009 model predicted that plume would continue migrating an additional 500 feet over the next 30 years and that the MCLs would be reached in another 50 years (i.e., in 2059). Based on 2014 and 2015 results, the plume has migrated almost 2,000 feet since 2009. Of the seven shallow and intermediate depth wells that monitor this plume, five show overall increasing trends. Additionally, MW-57, a monitoring well approximately 1,500 feet downgradient of the nearest OT069e well, has increased to above or at the TCE MCL for the past two years. There is overall poor delineation of this 100-acre plume in the downgradient direction. Based on the overall increasing trends in site monitoring wells and the plume's continued expansion into previously unimpacted areas and beyond what was estimated by the 2009 modeling effort, the plume is not stable and MNA is not adequate to prevent further plume migration or to restore water quality in a reasonable timeframe. According to the trigger of the "TCE concentrations exceed the MCL at a monitoring well where concentrations are predicted to remain below the MCL" cited in Table 5-1, active remediation should be considered. Additionally, plume migration is more easterly than the 2009 model predicted; therefore the designated trigger wells are not appropriate located to evaluate downgradient migration.

Comment 64: Section 5.5.2.1 Remedy Selection

The statement regarding state land use controls (SLUCs) should be revised since there are no existing SLUCs at the former GAFB properties.

Comment 65: Section 5.5.3.2 Risk Information

The Water Board does not agree that the groundwater pathway is incomplete. The site groundwater has potential beneficial uses and the impacts to those uses should be evaluated. Additionally, the Upper Aquifer could serve as viable domestic water supply, and the Lower Aquifer is a regional water supply aquifer. It is not clear that the Air Force has established that there are no users of the Upper Aquifer. See Comment 4. The contaminated groundwater of the Upper Aquifer should be included in a revised risk assessment. Additionally, the Air Force has not demonstrated that the contamination has not migrated into the Lower Aquifer and does not pose a threat to users of groundwater in the vicinity. This is especially of concern since the OT069e plume has increased in size significantly since the 1998 ROD for Operable Unit 3.

Comment 66: Section 5.5.3.2 Data Review, Plume Stability

The Water Board is concerned by the increasing trends at OT069e and the continued migration of the plume. See Comment 63.

Comment 67: Section 5.5.3.2 Data Review, Geochemical Factors

Please provide or reference where abiotic process have been demonstration. The 2009 model assumed there were not destructive methods including abiotic processes and attenuation was occurring through dilution and diffusion.

Comment 68: Section 5.5.3.2 Data Review, Geochemical Factors

The Water Board does not agree that the difference of detected TCE concentrations in MW-136 of 4.4 µg/L in 2013 and 4.0 µg/L in 2015 represents a decreasing trend in concentrations in this well. This difference is insignificant and within the range of normal variability of sampling and analysis.

Comment 69: Section 5.5.4.1 Question A: Is the remedy functioning as intended by the decision document? Implementation of ICs and Other Measures

This section should be revised to address Comment 64 regarding SLUCs and Comments 26, 27, 28, and 29 regarding ICs.

Comment 70: Section 5.5.4.1 Question A: Is the remedy functioning as intended by the decision document? Remedial Action Performance

Natural attenuation processes are not adequate to reduce concentrations to MCLs at OT069e and meet the RAO. Concentrations are increasing and the plume continues to migrate beyond what was predicted in 2009.

Comment 71: Section 5.5.4.1 Question A: Is the remedy functioning as intended by the decision document? System Operations/Operations and Maintenance

The Water Board does not agree that the existing monitoring is adequate to determine the effectiveness of MNA at OT069e. There is inadequate downgradient delineation of the plume and no monitoring of the Lower Aquifer.

Comment 72: Section 5.5.4.2 Question B: Are the assumptions used at the time of the remedy selection still valid? Changes in "Standards" and "To Be Considered"

The U.S. Environmental Protection Agency (USEPA) Directive, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, 1999 (USEPA MNA Policy), should be included as "To Be Considered." The USEPA MNA Policy outlines basic criteria and considerations for MNA, which OT069e does not meet, such as plume stability, adequate site characterization, and achieving goals in a reasonable timeframe.

Comment 73: Section 5.5.4.2 Question B: Are the assumptions used at the time of the remedy selection still valid? Changes in Exposure pathway

Water Board does not concur with the statement that the groundwater pathway is incomplete. See Comment 65.

Comment 74: Section 5.5.4.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy.

The Water Board does not agree that the answer to this question is "no." See Comments 63 and 65.

Comment 75: 5.5.5 Site OT069 Issues

Additional issues that should be included in this section are the following:

- According to the trigger of the "TCE concentrations exceed the MCL at a monitoring well where concentrations are predicted to remain below the MCL" concentrations in MW-57, active remediation of OT069e should be considered.
- Additional monitoring wells are needed in the downgradient portion of the OT069e Plume.
- The appropriateness of the existing triggers should be reevaluated since the OT069e plume migration is more easterly than the 2009 model predicted and the trigger wells are not appropriate located in this direction.
- Potential impacts to the Lower Aquifer from the OT069e plume should be investigated.
- The site should be evaluated in accordance to USEPA MNA Policy.

Comment 76: Section 5.5.6 Site OT069 Assessment

Water Board does not agree with the assertion that MNA has been effective at OT069e. See Comments 63, 65, 70, and 71.

Comment 77: Section 5.5.7 Site OT069 Recommendations and Follow-up Actions

Recommendations and follow-up actions should be revised to address the issues identified under Comment 75.

Comment 78: Section 5.5.8 Site OT069 Protectiveness Statement

The Water Board does not agree the remedy is protective in the long term. See Comments 26, 27, 28, 29, 65, and 71.

Comment 79: Section 5.7.1, Site ZZ051 Description and Background

The Water Board appreciates the additional actions planned for 2016. However, it unlikely that the additional evaluation will be completed in 2016, since it will entail additional soil sampling of polycyclic aromatic hydrocarbons (PAHs), a risk evaluation, and additional groundwater sampling to evaluate the detection of benzene at borehole SB28. The text should be revised to provide a more realistic estimate of time to complete.

Comment 80: Section 5.7.2.4, Site ZZ051 Progress Since the Last Five-Year Review.

The fourth bulleted item appears to be an incomplete statement. Additionally, the sixth bulleted item is redundant with the fourth bullet. Please revise for clarity and eliminate redundancies.

Comment 81: Section 5.7.3.2 Risk Assessment

This section should be revised to state that the risk assessment will also have to be revised based on the results of the additional soil sampling and analysis for PAHs.

Comment 82: Section 5.7.3.3. Data Review

The results of the groundwater sample for SB028 should be discussed in more detail. Specifically, the constituents of concern that were detected, included fuel and waste fuel related, such as PAHS, and the concentrations of the detections. The Water Board does not agree that these constituents of concern can be dismissed as from cross-contamination and additional characterization is necessary.

Comment 83: Section 5.7.4.2 Question B: Are the assumptions used at the time of the remedy selection still valid?

The need for additional evaluation of PAHs should be discussed under this question.

Comment 84: Section 5.7.5 Site ZZ051 Issues

Two outstanding issues that should be identified here are:

- The need for additional evaluation of PAHs
- The need for representative groundwater samples in the vicinity of SB28.

Comment 85: Section 5.7.7 Site ZZ051 Recommendations and Follow-Up Actions

This section should be revised to address the need for follow-up actions for the two issues identified in the previous comment.

Comment 86: Section 5.7.8 Site ZZ051 Protectiveness Statement

The Air Force's conclusion that the remedy is protective should be qualified pending the results of the additional evaluation of PAHs and groundwater contamination in the vicinity of SB028

Thank you for the opportunity to comment on the Five-Year Review. You may contact me at (530) 542-5471 (linda.stone@waterboards.ca.gov), or Cindi Mitton, Senior Water Resources Control Engineer, at (760) 241-7413 (cindi.mitton@waterboards.ca.gov), if you have any questions regarding this letter.

Linda Stone

Linda Stone, PG CHG

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LSt./ma/T: GAFB Draft Fourth 5YR
File Under: GeoTracker